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A NEW MOUNTING FOR A REFLECTING TELESCOPE.

By RUSSELL W. PORTER.

The problem of comfortably housing the astronomer when observing the heavens—whether he be professional or amateur—is a difficult one. Most observatories are so constructed that the temperature of the room in which the observer is working must be the same as that of the outside air, whether it be one hundred above or thirty below zero. There are a few notable exceptions to this general rule—the French Equatorial Coudè at Paris, the Sheepshanks Telescope at Cambridge, England, and the Hartness Turret Telescope at Springfield, Vermont—where, by means of an additional reflection, the converging beam from the telescope objective is bent and brought into a closed room maintained at a comfortable temperature. These instruments are all refractors and have proven very satisfactory for the work they were designed to do.

The reflecting telescope from its very nature, when adapted to the closed observing room, presents the problem in a new and entirely different aspect. In the two forms in which the reflector is ordinarily used, viz: the Newtonian and Cassegrainian, there are two reflecting surfaces and it has been supposed that a third mirror must be added to these two in order to bring the converging beams from the primary into the observing room. The writer, however, in 1915 built a reflector of sixteen-inch aperture with only two mirrors and brought the focus of the paraboloid into the den of his house where he could study the images of celestial objects in a warmed room. This telescope was used a great deal, especially on the moon* and much work was accomplished in the winter months that would never have been attempted out doors. There were, however, two defects. The eyepiece, although fixed, required that the observer look up the polar axis at an angle of nearly forty-five degrees. This position when held for a long time becomes uncomfortable. Moreover, certain parts of the northern heavens could not be reached with the mounting used.

In the form hereby submitted the writer believes that an entirely new relation has been established in the arrangement of the mirrors. In-

*Sc. Amer. Sup. No. 2170, Aug. 4, 1917 "An Amateur's Observatory."

spired by the convenience and rigidity of the turret, as developed by Hartness, these mirrors have been incorporated in the turret form of equatorial mounting, with the result that a very compact mechanical unit has been secured. The two mirrors are carried on a ring several feet in diameter that turns on ball bearings that are bedded into the walls of the observing room. This ring lies in a plane parallel to that of our equator and is really an expanded polar axis; that is, it takes the place of the two bearings of the polar axis of the ordinary equatorial mounting. Therefore, any part of the heavens seen through a telescope attached to this ring, if the ring is set turning opposite to the daily motion of the earth, will appear stationary in the field of view.

The concave mirror of the reflecting telescope is rigidly connected to the turret, with its focus inside the room, and its axis parallel to the equator. Near the focus, but outside the room, is a perforated flat mirror inclined at forty-five degrees to the optical axis of the paraboloid. This flat mirror is supported by a ring that is bedded into the turret at right angles to the equatorial ring, and takes the place of the declination axis of an ordinary equatorial mounting. It will be seen therefore that this flat mirror, capable of moving freely in declination and supported on the turret which revolves in right ascension, can reach and deliver to the concave mirror any part of the visible heavens, and that the concave mirror in turn reflects and converges the rays through the hole of the flat mirror to the focus inside the room. The observer looks down at a convenient angle, occasionally horizontal, never upwards. For photographic work there is no necessity of reversing the instrument when crossing the meridian, although for visual work it is desirable in order to keep the convenient posture of looking downwards. The eyepiece is not fixed but nearly so, moving in a circle of small diameter.

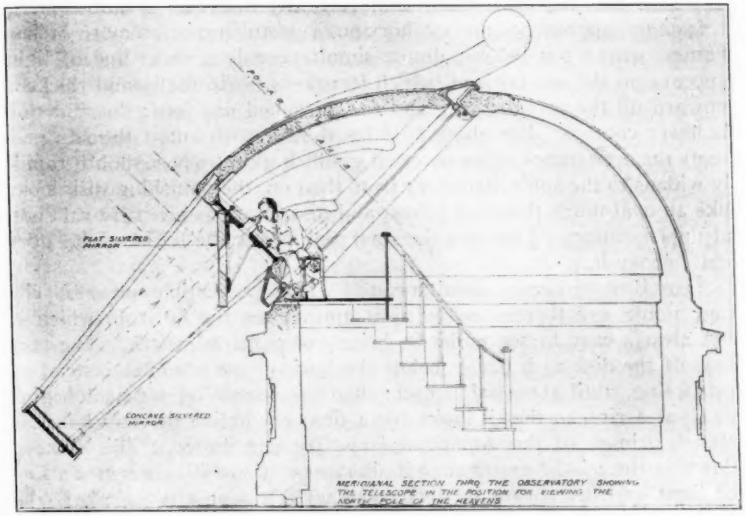
With such a large equatorial ring for applying the clock drive, a powerful leverage is found.

Counterpoising the telescope so that the turret may revolve freely is taken care of by thickening the concrete walls of the turret opposite the mirrors.

Astronomers will doubtless be somewhat shocked at first to see two large mirrors outside the observatory and wholly unprotected from the wind and weather. But it is believed that the form of mounting is so compact and stable that vibrations may not be feared. However, tubular housing may be used if found desirable without affecting in any way the general design. The Hartness Turret Refractor has proven very solid and free from wind tremors. The dome form of building to support the turret here shown is purely arbitrary. It will be recalled that in no position of the instrument is there any moving part below the plane of the equatorial ring, so that this allows considerable latitude in the design of the observatory. The spherical dome resting on cylindrical walls does, however, support the turret well, offers

no obstruction to the telescope in any position and lends itself to effective architectural treatment.

The increased cost of the large flat mirror must be justified. This must be found in the great advantage of working over long periods


FLAT SILVERED MIRROR
CONCAVE SILVERED MIRROR
MERIDIANAL SECTION THRO THE OBSERVATORY SHOWING THE TELESCOPE IN THE POSITION FOR VIEWING THE NORTH POLE OF THE HEAVENS

of time in a congenial atmosphere, in the ease of the observer's position when using a comparatively fixed eye-piece, the marked ease of control and manipulation, and the reduced cost of the mounting.

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November 26, 1920.

LOW SUN PHENOMENA—IV. The "Green Flash."

By WILLARD J. FISHER.

When the sun sets over a water horizon, its form as seen depends on the changing gradient of refractive index through all the atmosphere between the sun and the eye. The commonest form is when the gradient of refractive index is positive near the surface—the water slightly warmer than the air—though negative through the upper, greater part of the air. This is the condition for a surface mirage. Less common, but in some ways more remarkable, is the form when the normally negative gradient of refractive index begins right at the surface, with perhaps an intensification there. If the eye is not much above the water surface, these two forms occur with corresponding values of the

dip of the visible horizon, which is lowered in the first case as compared with its geometrical position, raised in the second. I will call these two forms types A and B.

Type A occurs always when mirage is perceptible, sometimes when it is not. As the descending sun, vertically flattened by atmospheric refraction, approaches the sea horizon, a protuberance of more or less flatness grows out below; almost simultaneously a short line of light appears on the sea horizon, which lengthens horizontally and thickens upward till the protuberance and the thickened line join; this junction is lower contact. For about half the duration of sunset the sun presents the appearance of an inverted goldfish globe, whose mouth rapidly widens to the sun's diameter; from then on, the vanishing disk looks like an oval much flattened below, and disappears as a small oval spot, at upper contact. This spot does not sink below the horizon—it "goes out", above it.

Type B never occurs simultaneously with a perceptible mirage. The descending sun flattens below as it approaches the horizon, which is not always easy to see under it, being comparatively dark. The corners of the disk as it passes below the horizon are rounded, instead of projecting, until about midsunset; than the remaining segment begins to show a rim, so that it looks for a time not unlike the "tin hat," or trench helmet, of the American Expeditionary Force. This flattens down in the middle faster than it shortens horizontally, becomes a line of light and disappears in dots and dashes among the waves, if the horizon is near. The disappearance is slow, not like the sudden vanishing of the spot at the end of type A.

Le Gentil,[1] who made a voyage to Ile-de-France (Mauritius), Pondichéry and Manila, to observe the transit of Venus in 1769 and to study atmospheric refraction in the tropics, thus describes the corresponding phases of sunrise at Pondichéry, as seen through the telescope of his quadrant:

"7 January 1769. . . . . the horizon was depressed 10′ 50″. I awaited the sun's appearance at the sea horizon, which I saw very distinctly; but when that heavenly body commenced to rise, it appeared *above* the sea horizon[2], a very remarkable fact which I had already noticed at Ile-de-France. When the sun was half risen, the horizon was further depressed, and seemed at a lower elevation than before by about three-fourths of the 50″ found before sunrise, i. e., by about 36″; the sun's center being completely up, the upper limb seemed to flow back on both sides from the sea horizon, and to take a form like the top of a vase; finally the lower limb let go of the sea horizon quite definitely above the horizon. The effect was singular; it seemed to me that a part of the top of the vase was pushed below the horizon, and

[1] Le Gentil, Hist. avec Mém. de l'Acad. Roy. des Sci., 1774; Mém., p. 330-350.
[2] In another place he says the sun appeared "as if from chaos."

that the remainder was joined to the sun by two pieces detached as by a chisel.

"9 January 1769. . . . . the horizon was depressed 10′ 50″, as on the preceding day.

"The sun appeared much above the horizon at 6^h 5′ 58″ 30‴; in proportion as the sun ascended, the horizon was depressed till it was at a less height than before by about a quarter of the 50″ found above, i. e., by 12″ or 13″. Finally the sun got away from the horizon quite above the horizon at 6^h 8′ 25″½; it had the effect of two suns which broke connection and separated, of which one descending toward the horizon did not disappear for 5 or 6 seconds after disconnection from the true sun."

(This was evidently a sunrise of type A.)

"14 July 1769. The sun appeared suddenly and exactly at the sea horizon; I saw a little trace or fillet of light gilding the horizon, and that fillet was the sun. That heavenly body appeared quite differently as compared with last winter; it was like a quite perceptible portion of an agitated fluid which suddenly made itself seen just over the horizon. . . . . Another fact to note is that the sun appeared with great brightness even at the horizon, for I could hardly bear its light the instant after it appeared, and had to take recourse to smoked glass when a quarter of the globe was up; but last winter I could easily endure the light, even when it was a degree above the rational horizon."

(The initial ribbon of light shows this to have been a type B sunrise; the rapidity of the appearance shows that it was not strongly developed.)

The atmosphere not only refracts but also disperses light. Consequently a low star, or, on account of the scintillation of the stars, better a low planet, seems drawn out into a short vertical spectrum, with red below. The length of this spectrum is variously computed as from 1/40 to 1/100 of the mean refraction, the extent depending on the limits of visibility assumed. But in any case, near the equator an equatorial star spectrum would set in about 1.3 secs., being about 20″ long; the duration of setting elsewhere of course depends on latitude and declination. The image of the low sun is bordered by lower and upper colored fringes, as it consists of images, red, yellow, green and blue in order upward, superposed but slightly out of register. Centrally these fringes are of width roughly half the length of a star spectrum, about 10″, and each would require about 0.7 sec. to set, or more, depending on latitude and declination. The lower orange red fringe shows sometimes indistinctly against the orange glow of the air; the upper bluish green is often dimmed by atmospheric absorption or scattering, which acts so strongly on short wave-lengths. Both may often be seen with telescopes of not very high power, with proper protection to the eye. As reflectors show them, they are evidently not due to peculiarities of the instruments.

A very much discussed and very much explained phase of sunset is

the "green flash"—blue ray, green ray, green light at sunset, green spot, emerald drop, rayon vert, soleil vert des matelots, punto verde, grüner Strahl, blaugrünes Flämmchen—and the much less frequently observed red flash. The former became known to wide circles, who otherwise would never have seen it, because Jules Verne in 1882 named a novel from it, "Le Rayon Vert"; Mrs. F. A. Steel also uses it in her novel, "Red Rowans." If the conclusions of W. Groff (50)* are correct, priority in its observation must be yielded to the ancient Egyptians, who, he holds, in consequence assigned to the semicircular symbol of the rising or setting sun the colors blue and green, and were influenced by their philosophy to extend these colors to the departed sun, journeying by night below the dark northern horizon, to the souls of the departed and to the gods of death, and to paint their mummies with these colors. The descriptions of Groff, Offord (109), and Piot-Bey (117) would indicate that in Egypt the display is more frequent and more splendid than anywhere else.

After the ancient Egyptians, J. P. Joule seems to have been familiar with it; possibly moved by him, D. Winstanley (161) made, and published through the Manchester Literary and Philosophical Society, the earliest systematic observations of which I find record. He says:

"It is recorded in the Proceedings of this Society that a letter dated from Southport and written by Dr. Joule was read at the meeting held on the 5th October, 1869. In that letter it is remarked that 'Mr. Baxendell noticed the fact that at the moment of the departure of the sun below the horizon the last glimpse is coloured bluish green'. Dr. Joule also observed that on two or three occasions he had himself noticed the phenomena in question, and that 'just at the upper edge where bands of the sun's disc are separated one after the other by refraction, each band becomes coloured blue just before it vanishes.' During the past eighteen months the writer, from his residence in Blackpool, has had frequent opportunities of observing the setting sun, and has noticed the phenomenon of the final coloured ray certainly more than fifty times. To the naked eye its appearance has generally been that of a green spark of large size and great intensity, very similar to one of the effects seen when the sun shines upon a well-cut diamond. The colour, however, is by no means constant, being often, as in the case of Mr. Baxendell's observation, bluish green, and at times, as mentioned by Dr. Joule, quite blue. The period of its duration, too, is likewise variable. Sometimes it lasts but half a second, ordinarily perhaps a second and a quarter, and occasionally as much as two seconds and a half. When examined with the aid of a telescope, it becomes evident that the green ray results at a certain stage of the solar obscuration, for it begins at the points or cusps of the visible segment of the sun, and when the 'setting' is nearly complete, extends from both cusps to the central space between, where it produces the momentary and intense spark of

*This and similar numbers in parentheses refer to Bibliography at end of the article.

coloured light visible to the unaided eye. From the facts of the green cusps being rounded I apprehend that irradiation contributes to the apparent magnitude of what is seen. The range of colour too as seen in the telescope is more varied and the duration of the whole phenomenon is more extended, than when the observation is made only with the naked eye. Respecting the increased range of colours seen when the phenomenon is observed with telescopic aid, I may mention that on the 28th of June the sea was calm and the sky quite cloudless at the setting of the sun. Of the final coloured rays fifteen diameters showed the first to be a full and splendid yellow, which was speedily followed by the usual green, and then for a second and a half by a full and perfect blue. Respecting the increased duration of the colour, I have found that when the atmosphere is sufficiently favourable to allow a power of sixty diameters being employed with a three-inch object-glass, the green effect is seen at that part of the sun's limb in contact with the horizon even when one half of the sun is still unset, and of course from then till final disappearance. The different colours seen, together with the order of their appearance, are suggestive of the prismatic action of the atmosphere as the cause of their production, and the interception of the horizon or the cloud as the cause of their separation. Assuming the correctness of this view, it becomes evident that an artificial horizon would prove equally efficacious in separating the coloured bands, and also that if employed during an inspection of the sun's lower limb, the least refrangible end of the spectrum would be disclosed. By projecting a large image of the sun into a darkened room I was enabled to get the whole of the spectrum produced by the prismatic action of the atmosphere in a very satisfactory manner. In this case a semicircular diaphram was used, so placed that its straight edge divided the field of view into equal parts, from one of which it obscured the light. The diaphram was placed in the focus of the eye-piece, and by rotating it every portion of the sun's limb could be in turn examined, and that too in the center of the field, so as to be equally subjected to the minimum of the peculiarities of the instrument. When the sun's lower limb was allowed to descend into the field of view the first rays were intensely red. After a momentary duration they gave place in succession to orange, yellow and green which were then lost in the ordinary refulgence of the sun. The upper limb gave green, blue, and finally purple, which latter colour I have thus far never seen upon the natural horizon. I apprehend that the results here given sufficiently prove that atmospheric refraction is the cause of the coloured rays seen at the moment of the sun's departure below the horizon."

Though never quoted in any of the numerous and scattered notes on the subject which have been printed since 1873, this description needs to be supplemented in details only.

Geographically, the flash over a water horizon has been recorded at the North Sea watering places and off the coast of Norway, on the

open North Atlantic, at many points on the coasts of Great Britain, on both coasts of France, on Mediterranean islands, in Italy, at Trieste, on the open Mediterranean, on the Red and Arabian seas, on the Indian Ocean, both near India and far to the south, on the South Pacific, off Vancouver in the North Pacific, in the South Atlantic, in the Gulf of Mexico, and off the Massachusetts coast; at either sunrise or sunset, depending only on the orientation of the coast. I have myself seen it with various brilliancies over Manila Bay, over the China Sea, on the Pacific between Nagasaki and Honolulu, and evening after evening near Honolulu. There is no record of it from high latitudes, either north or south, to my knowledge, unless the notes of H. Arctowski (3), 23 mars 1898, form an exception; in them the color of the disk itself is not mentioned.

This flash is seen not only over a water horizon; D. Winstanley (161) and A. A. Rambaut (123) constructed artificial horizons, diaphragms to be inserted in the focal planes of telescope objectives; others record it where the horizon was, according to S. Barker (6), "some high down land"; E. J. Cope (29), "the top of the hill"; E. Hawks (54), "over a hill"; C. T. Whitmell (155), "a land horizon"; H. R. Mill (91), "the rocky islet known as the Dutchman's Cap"; W. Swan (141) saw it eastward from the Rigi; Lord Kelvin (64), over Mt. Blanc; S. P. Thompson (24), "from Hampstead Heath, from Llanfairfechan, from Arran, and over the prairies in Manitoba"; J. J. Taudin Chabot (18), over a hill horizon in Germany and (21) at Rotterdam at sunrise; H. Crew (33) saw it from the Lick Observatory; E. Dorn (36), when the sun was setting over the Ötztaler Bergen; J. E. Clark (28) and Capt. A. Carpenter (15), with the sun setting over house roofs; W. Groff (51), Piot-Bey (117), J. Offord (109), Flinders-Petrie (112), and, according to Capt. de Maubeuge (89), "all tourists in Egypt", have seen it times without number inland in that country; de Maubeuge (89) and others saw it from the Gulf of Suez as the sun rose over the flanks of Mt. Sinai; A. Cowper Ranyard (124), in company with M. Perrotin and M. Thollon, saw it from the Nice Observatory, "as the sun at that period set over the bare edge of an opposite mountain"; A. Riccò (126), at Palermo, has seen it many times "at sunrise from behind the mountains Madonie or Cape Zaferano, which, from the Observatory, appear higher on the sea horizon than the sun's disc"; V. Turquan (143), saw it at both sunrise and sunset, over the Alps and over low hills; G. McK. Knight (66), at sunrise and sunset in Turin, Milan, Genoa, Pisa, Rome and Naples. C. T. Whitmell saw it in all sorts of situations, including one (149) in which his position was the bandstand at Woodhouse Moor, near Leeds, England, and the horizon was multiple, formed by the slats in a Wesleyan church belfry, which afforded several successive flashes, both green and red. I have seen it from near Honolulu, over distant mountains of Oahu, and twice from Kilauea, over Mauna Loa, near the summit.

The angular altitude of Mauna Loa at Kilauea was measured as

about 1 1/4°; from the date of de Maubeuge's observation, and from Map 102, Century Atlas, giving the height of Sinai, 8,540 ft., and the distance of the ship's route, about 67 km., there follows the apparent altitude of Sinai, less than 1° 55′. (This takes into account the earth's curvature, but neglects refraction. Capt. de Maubeuge gives it as about 10° above the horizon; but this must be a misprint—no liner captain could mistake an altitude so.) According to Baedeker's panorama and its altitudes, the eastern horizon seen from the Rigi was probably not above the rational horizon. I have no means of calculating Lord Kelvin's Mt. Blanc horizon.

R. T. Omond (111) saw the green flash over a sea horizon 70 miles away from Ben Nevis, altitude 4406 ft.; Father M. Selga, of the Philippine Weather Bureau, has seen the flash frequently over the China Sea from the Observatory on Mt. Mirador, Northern Luzon, 1512 meters high, where I have also seen it; H. B. F. (167) saw it frequently—thirty times out of fifty possibilities—from a veranda 664 feet above the eastern Mediterranean; Capt. A. Carpenter (12, 13), mostly from 700 feet elevation, in Sicily, twenty-one times out of forty-six possibilities; and A. Riccò and others (127), frequently from the Observatory on Mt. Etna.

The color of the sun's green flash is variously observed and described. Most observers agree with the range of colors given by Winstanley. By different observers of the same sunset the flash is not always described in the same terms. When the British Association was returning from its expedition to Cape Town, in the autumn of 1905, Dr. A. A. Rambaut (122) and Prof. H. A. Miers saw the flash one morning as "of a brilliant green colour, while another distinguished scientist who was standing near by preferred to describe it as blue".

The various color terms used in describing the "green flash" are given in Table 1.

TABLE 1.

COLOR OF THE SUN'S "GREEN FLASH"

Observer	Sun's Disk	Color, etc., of Flash
J. Franklin-Adams	.....	Brilliant emerald. No trace of haze or mist.
"Alpha Ceti"	Blood red	Bright green.
G. H. Baines	.....	Bright green, like a railway signal lamp.
T. B. Blathwayt	.....	Brilliant Prussian blue.
P. C. Campariole	.....	Pale green.
A. Carpenter	.....	Blue green knob.
A. Carpenter	.....	Blue green flickers. Cloud horizon.
A. Carpenter	White	White.
E. A. Childs	.....	Violet.
G. N. Clark	.....	White, blue and green in succession.
G. N. Clark	Gorgeously red	Like a beam of electric light, . . transparent and brilliant emerald.
E. J. Cope	.....	Beautiful green.
H. Crew	Deep red	to bright blue.
G. E. Danes	.....	Grayish blue, like an electric light burning mercury.

TABLE 1. (Continued)

COLOR OF THE SUN'S "GREEN FLASH"

Observer	Sun's Disk	Color, etc., of Flash
E. Dorn	.....	Intensive grüne Färbung.
T. A. Dukes	.....	Like green fire.
H. Ekama	.....	Blaugrünes Licht.
R. C. T. Evans	Golden edge	Apple green.
F. M. Exner	Dunkelrote Farbe	Fast weiss, prachtvolle smaragdgrün, blaugrün.
Flöckher	Rot	Grün . . komplementär.
W. Goodacre	.....	Bright metallic green.
W. Goodacre	Yellow	Most intense emerald green.
W. Groff	Flamboyant	Couleur verte brillante, éclatante, . . .une étoile de prémière grandeur, Venus ou Jupiter.
M. Hall	.....	Thin red line, bright red star, suddenly green.
J. A. Hardcastle	.....	Apple green.
E. Hawks	.....	Vivid green . . change to peacock blue.
G. H. Hopkins	.....	Brilliant emerald green.
W. H. Julius	.....	Jaune orangé . . verdâtre.
Lord Kelvin	Very little redness	White, green intense violet.
L. Libert	.....	Plus beau vert.
E. E. Marckwick	White	Bluish green point.
E. E. Marckwick	Reddish white	Green or bluish green.
H. de Maubeuge	.....	Vert émeraude, absolument pur et net.
Dr. Merrill (letter)		Violet, blue, green (very bright).
H. Metcalfe	Bright red	Beautiful pale green.
H. Metcalfe	Red	Faint flash.
H. Metcalfe	Blood red	Pale green.
"Meteor"	.....	Pale green, almost white.
H. A. Miers	.....	Brilliant green.
T. A. Molyneux	.....	Sparkling emerald green, white, gold.
A. A. Nijland	.....	Lebhaft smaragdgrün (ungefähr 0.53μ), gelblich grün, gelb.
A. A. Nijland	.....	Blassgrün . . . fahlgrün.
A. W. Porter	Red	Bright green (without any transition), complementary to the red of the sun.
A. Cowper Ranyard	Deep red	to blue.
C. Michie Smith	Brilliant golden red	Yellow to bright pea green.
Trève	.....	Absolument vert. d'une grande beauté.
C. T. Whitmell	Orange red	Green, like a luminous emerald.
C. T. Whitmell	Orange yellow	Bluish green.
C. T. Whitmell	Orange	Yellow, beautiful green, feather wisp of blue.
C. T. Whitmell	.....	Faint green.
D. Winstanley	Splendid yellow	Usual green, full and perfect blue; . . . well cut diamond.
J. F. Young	.....	Emerald green, like a beautiful scintillation of a diamond.
H. B. F.	.....	Most vivid emerald green.
H. B. F.	Bright golden colour	Brilliant green coruscation.
Lady at Trieste (by Exner)	.....	Flattened green disklet.

My own observations on the color of the "green flash" are given in Table 2. The initial numbers refer to a list of cases in which time data have been obtained.

TABLE 2.

COLOR OF THE SUN'S "GREEN FLASH"

For methods of observation, Nos. 26-42, see Philippine Journal of Science; Nos. 43-66, see notes to Table, "Low Sun Phenomena, V, Duration of Sunset"

No.	Date 1920	Place	Horizon	M	T	Color Disk/Flash	Notes: M = Mirage, intensity 0, 1, 2. T = Type, A or B.
26	I 23P	Manila Sea Wall	Bay all clear	1	A	Brilliant light yellow "Blue ray"	Air hazy Fr. M. Selga; eye.
28	I 25P	Manila Sea Wall	Bay clear	0	A	..... "Blue ray"	Air slightly hazy. Fr. M. Selga; eye.
29	I 26P	Manila Sea Wall	Bay clear	0	A	Very brilliant "Blue ray"	Little haze. Fr. M. Selga; eye.
37	IV 2P	San Fernando Pt. Lt. House	China Sea free	0	A	Yellow Brilliant blue spot	107 ft.; fish globe marked.
38	IV 3P	San Fernando Pt. Lt. House	China Sea clear	0	A	Very yellow Blue spot	Too brilliant for eye; fish globe slight; 84 ft.
39	IV 4P	San Fernando Pt. Lt. House	China Sea entirely clear	?	A	..... Blue spot	84 ft.
40	IV 5P	San Fernando Pt. Lt. House	China Sea clear	0	A	Brilliant yellow Blue spot like iron arc	84 ft.; fish globe very slight.
41	IV 6P	San Fernando Pt. Lt. House	China Sea	0	A	Very yellow Blue spot	84 ft.
42	IV 24P	Mt. Mirador Obsy., Baguio	China Sea visible	?	?	Yellow Blue thin line	1512 m.; not tin hat form; much horizontal distortion.
—	IV 25P	Mt. Mirador Obsy., Baguio	Transparent air level	—	—	Yellow Blue line split off from upper limb	
43	VII 27P	N. 32° 37′ E. 147° 35′	Pacific sharp, brilliant under sun	—	?	Yellow Brilliant green very marked	31 ft.; through chink between sea and clouds
44	VII 29P	N. 31° 56′ E. 157° 40′	Pacific sharp and clear	—	A	Yellow Green spot	31 ft.; slight flash, fish globe slight.
45	VII 30A	N. 31° 37′ E. 159° 34′	Pacific sharp	–	A	Very brilliant yellow Green spot	31 ft.; fish globe plain
46	VIII 4A	N. 27° 55′ W. 174° 41′	Pacific	—	A	Yellow Green	31 ft.; fish globe distinct

TABLE 2. (Continued)

No.	Date 1920	Place	Horizon	M	T	Color Disk/Flash	Notes: M = Mirage, intensity 0, 1, 2. T = Type, A or B.
—	VIII 4P	....	Pacific sharp	—	?	..... Green	Almost completely covered by clouds at one end of spot
48	VIII 7A	N. 23° 53′ W. 162° 08′	Pacific hazy	—	?	Yellow none	31 ft.; upper contact only.
49	VIII 7P	N. 22° 38′ W. 160° 01′	Pacific	—	A	Orange yellow to yellow orange Green, brilliant and long enduring.	31 ft.; upper contact only.
—	VIII 15P	Waikiki Oahu	Mountain	—	—	Very bright orange Bright green	U. S. A. reference mark 2178.
—	VIII 17P	Waikiki	Hills Cloud layer	—	A?	Bright orange Greenish Green	
—	VIII 18P	Waikiki	Air stratum Stratus cloud Low land with trees	—	?	Brilliant yellow Green line Green	
—	VIII 21P	Off Molokai	Low cloud	—	—	Orange No colored flash	
—	VIII 23P	Kilauea	Mauna Loa, near summit, 1 1/4° hazy	—	—	..... Narrow blue line rapidly disappearing	Too brilliant for field glass, used solar diagonal.
—	VIII 26P	Kilauea	Mauna Loa misty	—	—	..... Line of blue	Eye.
—	IX 3P	Off Kawaihae at anchor	Pacific clear and sharp	0	B	Yellow Bluish line	20 ft.; definite tin hat shape.
50	IX 4P	Waikiki	Pacific clear	1	A	Yellow Blue green spot	11 ft.; drop and reflection red.
51	IX 5P	Waikiki	Pacific sharp	1	A	Yellow Blue, like iron arc	11 ft.; fish globe rim red; upper contact only.
—	IX 7P	Waikiki	Pacific	0	A	Very bright and yellow Greenish blue line	Type A slight.
52	IX 10P	Waikiki	Pacific sharp	?	A	Very yellow Broad bluish line	9 ft.

53	IX	11P	Waikiki	Pacific sharp, nearly clear	2	A	Quite yellow Greenish spot, somewhat confused	9 ft.
54	IX	13P	Waikiki	Pacific sharp	1	A	Yellow orange not brilliant Bluish green wisp	9 ft.; cirrus clouds; drop and reflection reddish orange.
55	IX	14P	Waikiki	Pacific sharp	1	A	Very brilliant and bright Wisp, almost blue violet	9 ft.; drop and reflection reddish orange.
56	IX	16P	Waikiki	Pacific sharp and clear	1	A	Yellow, slightly dimmed Yellowish	9.5 ft.; type slight.
57	IX	17P	Waikiki	Pacific sharp and clear	1	A	Very yellow and brilliant Blue gray wisp	10 ft.; drop and reflection orange red.
58	IX	18P	Waikiki	Pacific sharp	1	A	Very brilliant yellow Violet blue spot	11 ft.; drop and reflection reddish.
59	IX	20P	Waikiki	Pacific sharp	?	A	Very yellow Bluish wisp	11 ft.; drop and reflection orange
—	IX	21P	Waikiki	Low cloud	—	—	Yellow No sign of colored flash	
60	IX	23P	Waikiki	Pacific sharp; spindrift	0	A	..... Blue gray elliptical spot	11.5 ft.; drop and reflection orange red.
—	IX	24P	Waikiki	Cloud	—	—	Yellow	
61	X	22P	Woods Hole Mass.	Buzzard's Bay clear and sharp	0	B	Blue flash Very yellow	6 ft.; lower air boiling; line extraordinarily long enduring.
62	X	23A	Woods Hole	Vineyard Sound hazy	2	A	Thin orange line Brilliant orange Greenish yellow	4 ft.; type strong; spot appeared above the horizon.
63	X	23P	Woods Hole	Buzzard's Bay boils and flutters	2	A	flimmering spot Brilliant Flimmering spot, orange,	4 ft.; type strong; spot high above horizon.
64	X	24A	Woods Hole	Vineyard Sound fairly sharp	2	A	bluish and violet marks in it Brilliant yellow Greenish spot	3.5 ft.; type strong; spot above horizon. no definite flash.
65	X	25A	Woods Hole	Vineyard Sound quite sharp	0	A	Yellow, not brilliant Green to yellow ellipse	4 ft.; sunspot visible before lower contact; type slight.
66	X	27A	Woods Hole	Vineyard Sound sharp, easily visible	0	B	Brilliant yellow Yellow line	Marked tin hat form; hazy beyond horizon.

While observing the duration of sunset from the Manila sea wall I had often seen the red lower border and the collapsing green lining of the vanishing segment, but these were not so brilliant as to overcome a prejudice for interpreting oddities as due to errors of observation, particularly as the telescope used was not quite color-free. However, Father M. Selga, of the Manila Observatory, informed me of the "blue ray", for which I have since constantly looked. The observations of the "blue ray" against which his name stands were made by him on evenings when I noted duration, form, etc., but was as yet ignorant of the flash phenomena. These composite observations are not therefore less valuable.

To explain these colors of the setting sun several theories have been proposed; the sea wave theory, the contrast theory, the dispersion theory of Winstanley and the anomalous dispersion theory of W. H. Julius (61). A suggestion made by W. Swan (141) is interesting, but has never been developed into a theory or tested in any way. The same may be said of a suggestion of J. Evershed (44).

The theory that the green or blue flash is due to sunlight shining through the crests of waves on the distant horizon, or even through the curved water surface of the ocean, is a natural one and has apparently suggested itself to several quite independently. The numerous observations of the flash, green or blue, over a land horizon are a sufficient argument against this.

The theory that the flash colors are due to retinal fatigue and simultaneous or successive contrast, giving subjective sensations of colors complementary to those of the sun's departing disk, is also natural and stoutly defended. R. C. Cann Lippincott (73, 75) has been long and frequently favorable to this theory, basing his arguments on experiments and observations his own and others, particularly on certain in Goethe's "Farbenlehre"; W. H. Pickering (105) suggested it also. W. Swan (141), whose notice in "Nature" was the first published after Winstanley's, regarded it as "purely subjective, for before sunrise the sky was all lit up of a magnificent crimson hue", and adduces other evidence of simple experiments. A. W. Porter (119) held this to be the explanation of the sunset flashes seen by him, and, with E. Talbot Paris (120) contrived an artificial sunset, in which a round hole covered with red glass or red gelatine film, and through which a bright light shone, set behind a card horizon. "It was easily possible in this way to obtain a red ray using a green sun, or a blue ray with a yellow sun, and so on." A. Schuster (135) holds that this explanation cannot explain the occasional brilliancy of the initial green flash at sunrise. He thinks that redness of the sun is a hindrance to the appearance of the green flash, instead of producing it. W. Flinders Petrie (112) says the same. R. T. Omond (111) says of the momentary green flash which he observed from Ben Nevis, "This was quite different from the complementary green seen after looking at the setting sun—brighter and bluer in tint." E. L. G. (165) says, ". . . no sunset, in any latitude, has a color complemental to green. The very

rosiest is only opposite to some cold blue, as Prussian blue . . . ." While I would hardly go so far as that, still, as H. B. F. (168) says, "the *ray* has not that dull appearance noticeable in this and other similar optical illusions, nor has it the like permanency." The reference in the table of colors to a railway signal lamp, a beam of electric light, green fire, a star of the first magnitude, sparkling emerald, scintillation of a diamond, green coruscation—all substantiate the impression of live color which I received on seeing the flash "brilliant blue" over the China Sea, 1920 IV 2, from the balcony of the light house on San Fernando Point, or "brilliant and long enduring green" over the Pacific Ocean, 1920 VIII 7.

Further, W. Flinders Petrie says that "At any distance less than five miles the disappearance can be followed up for some seconds by walking up a slope, so as to keep the green edge under continuous observation." C. Mostyn (103) and A. A. Nijland (107) report instances in which the flash has appeared as many as three times at one sunset, as big waves heaved up the ship opportunely, "causing as it were two sunsets with a sunrise between them."

Not the least argument against the contrast theory arises from its ill understood capriciousness. As D. Wilson-Barker (7), then Capt., R. N., says, "It should be noted that the green or any other coloured ray is not always seen even when the sun sets at sea on a perfectly clear horizon." But groups of witnesses who have the least idea where to look and are (occasionally) instructed to avoid dazzling the eye, agree in seeing it or not seeing it; as, witness, Biart (8), Flöckher (69), Hall (52), Marckwick (85), de Maubeuge (89), Mostyn (104), Nijland (107), Pickering (116), Rambaut (122), Cowper Ranyard (124), Turquan (143), Whitmell (151), Wölffing (162), H. B. F. (167), and the group on the bridge of the "Sheridan," on the Pacific Ocean, 1920 VIII 7. In all these cases groups of from two to twenty, in some cases ignorant of the phenomenon, in others skeptical, saw it at sunrise or sunset. H. B. F. and his wife made a long series of observations, he, moved by reading "Le Rayon Vert," she being at first skeptical, and with agreement in their results, positive and negative. Of the group on the "Sheridan", only the writer had ever seen the colored sunset flash, and the officers—Captain and Second Officer—and the quartermasters were decidedly skeptical and convincingly surprised.

However, the psychological explanation is by no means to be ignored, for it suggests precautions to be taken in making such observations with the naked eye; illusions seem to be much less important with a field glass or telescope, when the stages of the phenomena can be separated; there are some who hold that the subjective explanation is all-sufficient. H. H. Kritzinger (69) details the experiments of Kühl, not dissimilar to those of Porter and Paris, but with the variation that the artificial sun is given a trembling motion as it sets, which is said to cause the colored flash seen to be much enhanced in brilliancy. This trembling is held to be the equivalent of the flimmering and quivering

TABLE 3.

Observer	Duration seconds	Horizon	Place	Notes
J. Franklin-Adams	1.5 + 1.5 = 3	sea	Machranish	by counting; field glass
"Alpha Ceti"	about 2	sea	Blackpool	about 10 secs. lag after sun.
Anderson, Merrill St. John	not over 2	mountain	Mt. Wilson	letter
S. Barker	barely 2	"down land"	Haslemere	field glass
P. C. Campariole	about 1/4	sea	Voyage, Antigua-Trinidad	lag 1 sec.
A. Carpenter	1.5 to 2.5	sea	Taormina	field glass; elevation 700 ft.
G. N. Clark	about 4	sea	Southport	
G. E. Danes	a moment	sea?	Alderney L. H.	
W. G. Duffield	rather more than 1/2; 3/4	sea	Voyage, England-Australia	
T. A. Dukes	1 or 2	hill	Surrey	
H. Ekama	perhaps 2	sea	Zaandvoort	
F.M. Exner	(1) 1, (2) 0.3 — 0.5	sea	Trieste	(1) white, (2) green.
Flöckher	only about 1	sea	Zaandvoort	
W. Goodacre	3 - 4	sea	Indian Ocean	usually an instant
Maxwell Hall	(1) about 3 (2) about 1/2	sea	Jamaica	(1) red star, (2) green
J. A. Hardcastle	2	?	Italy	
E. Hawks	5 + 1 = 6	land	Leeds	5 while sun in sight, 1 after.
W. H. Julius	perhaps over 2	sea	Voyage, Holland-Java	
Lord Kelvin	less than 1/20	Mt. Blanc	Hotel du Mt. Revard	only blue mentioned
H. H. Kritzinger	hardly a second	sea	Söndervig	
F. C. Lees	perhaps 7	sea	Southport	
E. E. Marckwick	not more than 2 or 3	sea	leaving Gibraltar	
H. Metcalfe	2 or 3; 1/2	sea	Fleetwood	
A. A. Nijland	15; 1/2 or 1; 1	sea	circumnavigation	
J. W. Scholes	2 or 3	sea	Morecambe	
C. M. Smith	several	sea	off Vancouver	
C. T. Whitmell	perhaps a couple	land	near Leeds	

of the sun's upper limb not seldom seen near the horizon. Personally, I believe that the psychological explanation seems much more convincing to persons who have seen the sun's departing flash only once or twice, and with the naked eye, or who have only read about it.

The simple dispersion explanation is accepted, nearly as it was first put forward by Winstanley in the extract quoted above, by W. J. Humphreys (59) and by A. A. Rambaut (123), as explaining the "green flash." F. M. Exner,[1] however, holds that the phenomenon is not yet completely explained. Some of its difficulties are variable duration, capriciousness, appearance on a cloud but not at a clear sea horizon below, and occasional lack of color.

Its duration is very variable; even though we admit that some of the observers have been inexperienced in the estimation of short intervals, some of them equally have not been. In Table 3 I have collected statements about this duration, from the various notices at hand.

It is to be seen there that the shortest estimate is Lord Kelvin's, 1/20 second, over the high horizon of Mt. Bianc; the others vary from more or less than 0.7 sec., which is the minimum computed above for the setting of the upper fringe of an equinoctial sun at the equator, to several times that; to 3-4 secs., according to W. Goodacre, who was surprised at this, and even to 15 secs., in the case of A. A. Nijland, who seems to have been careful in observing and recording. These deviations are too large to be ascribed to latitude and declination[2], and equally difficult to lay to changes in the relative dispersion of the air, unless some factor enters in which has not hitherto been mentioned. I have no measurements of my own to add, but can say that the duration of the flash, green or blue, certainly varies widely, and so also does the width of the green or blue segment of the setting or rising sun. Estimates of this latter have been made by A. A. Nijland, in one case 4′, in another 4′?; by W. Goodacre, 1′ and 3′-4′; and by A. Carpenter, 1/10 of sun's disk. These estimates would correspond to durations of from 4 secs. to 16 secs. at the equator and equinox, and to more with different latitudes and declinations.

(To be continued.)

[1] Pernter-Exner, Meteorologische Optik, p. 798-799.

[2] Assuming the fringe on the sun's upper limb to be 10″ wide, and comparing the durations of the setting of this fringe at the equator and at Greenwich, as so many of the observations have been made in European latitudes, then for the summer solstice the duration would be 0.73 sec. at the equator, 1.30 sec. at Greenwich; for the autumnal equinox, 0.67 sec. at the equator, 1.07 sec. at Greenwich.

THE PLANETOIDAL HYPOTHESIS.

By W. H. PICKERING.

The Planetoidal Hypothesis, with one important addition, is so strikingly illustrated in the case of the recent measures of Betelgeuse, and the Gaseous Hypothesis appears to be so hopelessly inadequate to account for its condition, that it seems worth while to refer to the matter again in this connection. According to the latest measures the parallax of the star is 0″.018, and its apparent diameter 0″.046. Expressing these quantities otherwise, it appears that its distance is 56 parsecs, or nearly 183 light years, and its diameter 240,000,000 miles, or 275 times that of the sun.

We will first treat the subject from the standpoint of the generally accepted gaseous hypothesis. This has already been discussed in POPULAR ASTRONOMY 1920, **28**, 80, but we then had only a hypothetical case to deal with. We now have the actual dimensions of a star on which to base our computations. It is known that the masses of all the stars are of the same order of size, but in order to make the best possible case for the gaseous hypothesis, let us assume that the mass of Betelgeuse is 100 time that of the Sun,—greater than that of any star that has hitherto been measured. Its density is then 1/210,000 in terms of the sun, or 1/190 in terms of our atmosphere at sea level. That is to say its average density, even adopting this great mass, is only that of a gas under the receiver of an air pump where the pressure is 4.0 mm. The force of gravity at its surface would be 1/760 that at the surface of the sun, or less than one-fourth that at the surface of the moon. Now we know that the cool moon can only retain a slight atmosphere by the force of its gravity, how much less then could any amosphere be retained by the incandescent Betelgeuse with but one-fourth of this gravitational attraction. The star would necessarily fly apart and be dissipated in space, without even considering the effect of the repulsion of light.

Turning now to the planetoidal hypothesis, let us in addition to the data given in the above mentioned article, assume that a luminous star can only be generated by the gradual and continued collision of two groups of planetoids. Planetoids have, as already stated in connection with the origin of *novas*, been assumed to occur only, or mainly, in the regions of the Milky Way, and that is in fact also where the giant red stars are mostly found at the present time. The planetoids have been assumed to average 1,000 miles in diameter, and to have a mass equal to one-eighth that of the Moon. In order to fix our ideas let us assume this figure to be correct. It would therefore take 200,000,000 of them to make a body of the mass of our sun. Some of them would doubtless be much larger than the average, perhaps of the size and mass of our earth, and some much smaller.

Let us assume two groups of planetoids, each containing 10,000,000,000 bodies of this average size, moving through space towards one another. Their united mass would then be equal to what we have assumed for Betelgeuse. The shapes of these groups would in general be globular, and their diameters that of the orbit of one of our outer planets, such as Neptune. In general the groups would be likely to miss one another and pass in hyperbolic orbits. Occasionally, however, there might be a glancing collision. If the collision was sufficiently direct, enough motion might be lost to establish elliptical orbits. Collisions would then occur with some frequency, the planetoids melting instead of being reduced to dust, and thus constantly increasing in mass. With the increase in mass and loss in motion, the groups would contract their centers would approach, and they would ultimately coincide. The luminous phenomena produced in connection with the collisions would for a time increase in brilliancy and frequency. The star would become an irregular variable, like Betelgeuse, and many others of types M and N. From this point on, the evolution from numerous distinct solid bodies to a single gaseous mass, different portions of which revolved at different speeds, would be continuous.

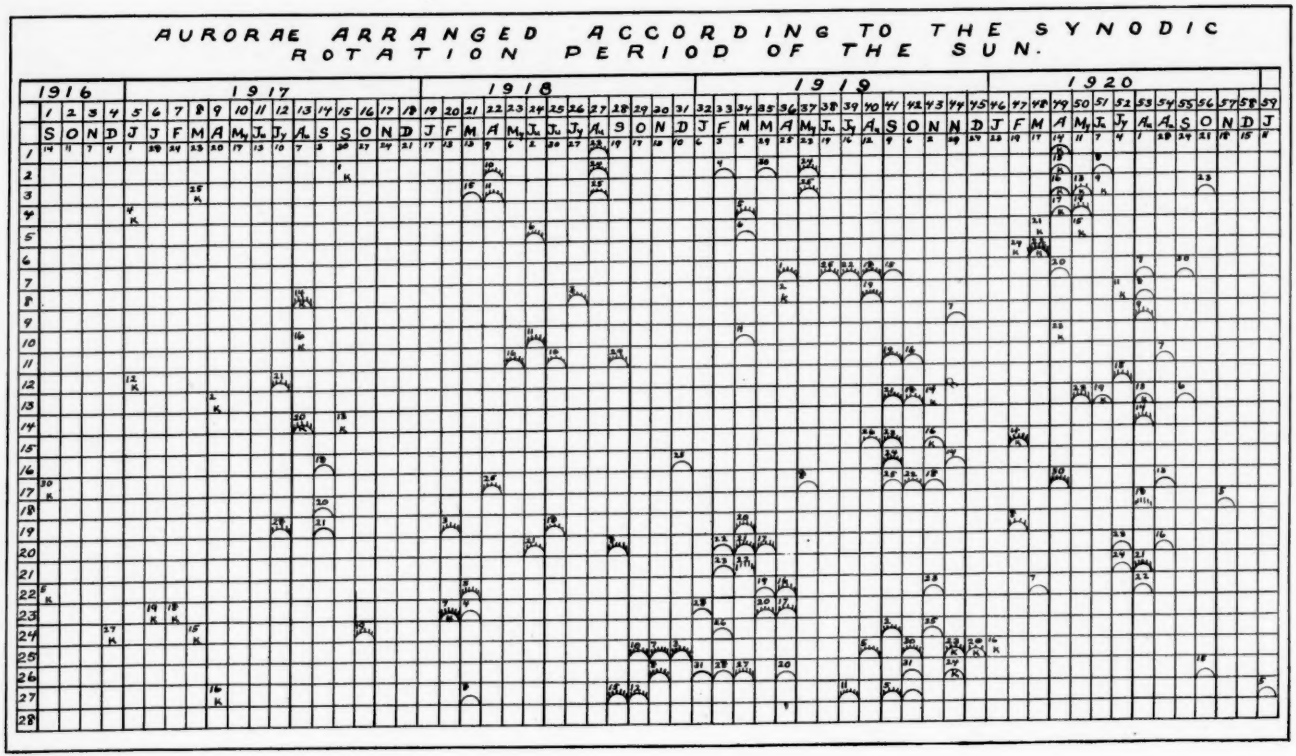
Mandeville, Jamaica, B. W. I., March 24, 1921.

AURORAL OBSERVATIONS.

By DAVID A. BLENCOE.

Since July 1, 1917, I have observed auroral manifestations on 124 nights, distributed by years as follows: last half of 1917, 7; 1918, 26; 1919, 56; and 1920, 35. Thus according to my observations the maximum auroral frequency occurred during 1919 which is about two years later than the sunspot maximum.

On the accompanying chart I have arranged these observations according to the synodic rotation period of the sun (27¼ days). The second line represents the number of synodic rotations of the sun from September 14, 1916. The third line contains the letters standing for the names of the months. The fourth line (which corresponds to the first day of each synodic period) contains the date for the first day of each synodic period. Thus, the first day of the first synodic period is September 14, 1916, and the first day of the second synodic period is October 11, 1916, and so on. The ¼ day is taken care of every 4th period and these are indicated by a heavier vertical line. When the auroral manifestation was simply an arch it is shown by an arc, and when streamers or curtains were present with the arc, by an arc with short parallel vertical lines resting upon it, and when streamers or curtains were visible but no arc, by a series of short parallel vertical lines placed to suggest an arc. The degree of brilliancy is indicated


AURORAE ARRANGED ACCORDING TO THE SYNODIC ROTATION PERIOD OF THE SUN.
1916
1917
1918
1919
1920

by the heaviness of the arc and streamer lines. The date on which the phenomenon took place is also indicated.

Mr. John Koep who observed at Chippewa Falls, Wisconsin, about forty miles northwest of here, kindly furnished me with his observations and these I have shown on the chart by simply the letter K and the date. It will be seen that Mr. Koep observed the aurora on many of the nights that I did. It will also be noted that the aurora repeats itself in a large number of cases according to the sun's synodic period of rotation. I have used this in predicting the recurrence of the phenomenon with some success. There also appears to be a 57 or 58 day period indicated as in 1918, Apr. 10-June 6, June 6-Aug. 3, Aug. 3-Sept. 29, Sept. 29-Mar. 21, 1919 (3 periods). 1919, Mar. 5-May 5, Mar. 21-May 17, Aug. 19-Oct. 16, Sept. 21-Nov. 17., also Jan. 29-Mar. 27. This period is twice the synodic rotation period of the sun plus 2½ or 3½ days, which excess of time may be due to shift of spot on sun's surface of about 2½° or 3½°, if we regard auroral manifestations to be due to sunspots or other solar activity as seems quite certain that they are.

In several cases cloudy weather prevented observations being made or I would very likely have seen northern lights on many of the missing synodic periods, especially so in 1919.

Alma Center, Wis.

TWENTY-FIFTH MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY.

ABSTRACTS AND PAPERS.

(Continued from page 229.)

COMPARATIVE TESTS OF THE 100-INCH AND 60-INCH REFLECTORS.

By F. H. Seares.

To test the two instruments for limiting magnitude and resolution, several series of photographs have been made under identical conditions with the assistance of Messrs. Hubble and Duncan. Equal exposures were made simultaneously with the two telescopes to the same field, using plates from the same box, which were afterwards developed in the same tray. To eliminate the influence of accidental variations in the sensitiveness of the plates, two or more photographs of the same field were made in each series.

		100-inch			60-inch			
Date 1920	Exp. m	Images	Seeing.	Limit	Images	Seeing	Limit	Gain Mag.
May 22	5	Large, Sl. El.	5	18.36	Excellent	6	17.82	+0.54
	3	Large, El.	5	17.84	Sl. El.	6	17.42	+0.42
	3	Large, Sl. El.	5	17.83	Good	6	17.61	+0.22
Aug. 14	2	Good	4	17.67	Sl. El.	4	16.88	+0.79
	2	Good	4	17.64	Good	4	16.82	+0.82
	2	Good	4	17.65	Good	4	16.85	+0.80
Aug. 15	2	Good	6	17.75	Poor, El.	6	16.67	+1.08
	2	Good	6	17.80	Sl. El.	6	16.88	+0.92

May 22. Not representative of the performance of the 100-inch. Images very large as compared with those of Aug. 14 and 15. Mirror astigmatic; figure of 60-inch excellent.
Aug. 14. A fair test of both instruments. Note consistency of limits.
Aug. 15. Gain for first pair too large because of poor images on 60-inch plate. The second pair is a fair comparison.

The results for limiting magnitude are shown in the accompanying table. All the photographs were on Seed 30 plates, exposed to Selected Area 87 for which the photographic magnitudes on the normal scale, referred to the international zero point, are well determined. The limit was obtained by selecting ten or twelve stars on each plate, just faintly visible, and estimating in tenths of a magnitude the interval separating their images from the limit. The known magnitude, plus the estimated interval, thus gives for each star a value of the limit. The tabular values are the mean results for each plate. The probable error arising from the estimates is 0.03 or 0.04 magnitude.

For a 2^m exposure on Seed 30 plates we may accept as representative

Seeing	100-inch	60-inch	Gain
4	17.6	16.8	0.8 mag.
6	17.8	16.9	0.9

Inasmuch as the theoretical gain of the 100-inch over the 60-inch reflector for ideal figure and perfect atmospheric conditions is 1.12 magnitudes these results are to be considered as very gratifying.

A similar plan was followed in the tests of resolution, the fields in this case being the central part of the extended nebulosity M 8 and the planetary nebula N. G. C. 7009 which is especially rich in fine delicate detail. One pair of plates on the Ring Nebula in Lyra was also made, but the 100-inch plate is defective through faulty guiding. Of M 8 seven pairs of plates were made with exposures of from 3^m to 15^m, the seeing ranging from 3 to 5 on a scale of 10. N. G. C. 7009 was photographed on a single pair of Seed 23 plates with exposures of 20^s, 1^m, 3^m, and 9^m. For examination corresponding pairs of negatives were mounted together on a measuring machine supplied with an additional microscope, so that the observer might look quickly from one plate to the other in comparing the details photographed with the two instruments. The magnification was adjusted to bring the image of the 60-inch plate to the same scale as that of the 100-inch.

Extended masses of nebulosity show the same density, as was to be expected since the two instruments are of the same focal ratio. But in resolution, a glance is sufficient to show the superiority of the 100-inch over the 60-inch, even in the case of M 8, photographed at a zenith distance of 60° with seeing as low as 3.

The results for the 100-inch Hooker telescope in the case of N. G. C. 7009, photographed at zenith distance 46°, seeing 6, are very much the superior of the two. Fine details are clearly shown which cannot be traced on the 60-inch negative, or at most are only suggested by irregular and undefined masses of silver grains. It is noteworthy too that

small details approximating star images in size, such as the ansae, are stronger on the 100-inch negative than on the 60-inch, although the relatively large central part of the nebula is strictly comparable in density on the two negatives.

Greater resolution is of course to be expected from the larger instrument because of the increase of scale in the ratio of 10 to 6, provided the linear increase in the excursions of the optical image do not nullify the advantage thus derived. These tests show conclusively that there is a decided gain in resolution with seeing as low as 3 on a scale of 10.

SECULAR MOTION OF PERIHELION DUE TO THE DRAGGING OF A COMPRESSIBLE AETHER.

By L. Silberstein.

In connection with the author's previous paper on the "Recent Eclipse Results and Stokes-Planck's Aether" (*Philosophical Magazine*, London, 1920) the problem of planetary motion is considered in which the planet behaves (due to the varying amount of aether dragged along in different parts of the orbit) as having a *variable* mass m, both inert and gravitational, to-wit $m = m(r)$, any given function of the distance from the central body. If $\mathbf{r}$ be the vector from the sun to the planet, the differential equation of motion is, with M written for the sun's mass in astronomical units

$$\frac{d}{dt}(m\dot{\mathbf{r}}) = -\frac{Mm}{r^3}\mathbf{r}. \tag{1}$$

It is shown that whatever the dependence of m upon r, say

$$m = m_0(1+\sigma), \tag{2}$$

where σ is any function of r alone, a first integral of the equation (1) is

$$r^2\dot{\theta} = \frac{k_0}{1+\sigma}, \tag{3}$$

where $k_0 = \text{const.}$, and r, θ are polar coördinates. This integral together with (1) gives the differential equation of the orbit

$$\frac{d^2\rho}{d\theta^2} + \rho = \frac{M}{k_0^2}(1+\sigma)^3, \tag{4}$$

which holds rigorously, as well as (3).

If σ is a small fraction of unity, (4) gives a conic, say an ellipse, with slowly moving perihelion. If e be the eccentricity of the orbit, the perihelion motion per period of revolution is given by

$$e\,\delta\omega = \int_0^{2\pi} \frac{\sigma d\theta}{\cos(\theta-\omega)},$$

with the approximate, undisturbed value

$$\frac{M}{k_0^2}[1 + e\cos(\theta-\omega)]$$

to be substituted for ρ appearing in σ. Thus, for instance, developing σ into a power series, $\sigma = a_1 \rho + a_2 \rho^2 + \ldots$, the corresponding motions $\delta\omega$ can at once be calculated. If the first term only is retained that is to say, if

$$m = m_0 (1 + \frac{a_1}{r}),$$

the perihelion motion is

$$\delta \omega = \frac{2 \pi a_1}{a (1 - e^2)}, \qquad (5)$$

a being the semi-major axis. Comparing (5) with Einstein's formula,

$$\delta \omega = \frac{6 \pi M}{a c^2 (1 - e^2)},$$

we see that in order to account for the observed excess of the perihelion motion of Mercury we should have, not necessarily as a general relation, but numerically, $a_1 = 3M/c^2$, i. e., an apparent increase of mass

$$\delta m = m - m_0 = 3 \frac{M m_0}{c^2 r},$$

amounting, in the case of Mercury, to little more than three in one hundred million parts. Whether such fluctuations of the planet's mass, either by dragging an aether or by gathering stray particles and giving them up again, are admissible or not, remains an open question.

SPECTROGRAPHIC OBSERVATIONS OF THE ROTATION OF SPIRAL NEBULAE.

By V. M. Slipher.

In the course of the spectrographic study of the spiral nebulae several objects have been found to show evidence of rotation. The observations have been secured with a spectrograph attached to the 24-inch Lowell refractor. For the most part the dispersion piece has been a 64° prism of very dense flint glass, but for a few of the brightest nebulae two 64° prisms of somewhat less dense glass were advantageous. The linear scale of these spectra, while the highest yet obtained, is low compared with that feasible for star spectra. However, owing to the high velocities of the spirals the percentage accuracy of the observations is comparable with that of star velocities. In observing for rotation the inclination method has been employed, the slit of the spectrograph being placed over the major axis of the nebula. Details were given and slides shown of the spectra of N. G. C. 221, 224, 1068, 2683, 3623, and 4594, there being evidence of rotation in each case.

It is of interest to consider the direction of the rotation of these nebulae relative to the curvature of the spiral arms because of its bearing on the evolution and the nature of spiral nebulae. But to interpret the spectrographic rotations it is obviously necessary to know in each case which side of the nebula is the nearer us. We are not yet able to determine directly the distance of any of the spirals,

but as I have previously pointed out I found some years ago an indirect means which is apparently dependable in the general case for deciding which is the nearer edge of an inclined spiral. Edge view spirals are commonly crossed by a dark lane or band, which obviously belongs to the nebula and has its origin in phase effect or occulting matter on our edge of the nebula. Nebulae tipped a little to the line of sight will still show this dark lane but somewhat shifted to the side. Still more tipping of the nebular plane to the line of view seems to cause the dark lane to resolve into rifts, and its presence to be evident in these and the deficient illumination of the spiral on that side of the major axis. This dissymmetry of the inclined spirals is a very striking feature. A grouping of the spirals beginning with those presenting their edge and following with those of more and more tipping to the line of sight shows strikingly how the dark lane gives way to the dark rifts and deficiency of illumination as the tipping angle increases. These effects remain until the spiral plane is tipped away from the line of view at a rather high angle.

Considering then that side of the inclined spiral having the darker rifts and deficient illumination to be the one nearer us, we can interpret the direction of the rotation, shown by the spectrograph, relative to the curvature of the spiral arms where arms are recognizable. In every case the spectrographic results were got independently of any knowledge as to the nearer edge of the spiral and the location of the spiral arms, and likewise these data as to orientation were determined quite independently of the rotation shown by the spectrograph.

The six nebulae discussed all agree in showing rotation in the same direction relative to the spiral arms. The direction is that in which the arbor of a spiral spring turns when the spring is being wound up. It was finding such observational evidence as this that led me several years ago to suggest that we must entertain the view that there are systems, at least among the spirals, that are expanding just as there are others that are contracting.

PHOTOGRAPHIC DISTORTION ON ECLIPSE PLATES AND THE EINSTEIN EFFECT.

By Frederick Slocum.

Among the many attempts to explain the displacement of stars on the 1919 eclipse plates has been mentioned photographic distortion, due to the large area burnt out by the corona near the center of the plate.

Ross, in the *Astrophysical Journal*, **52**, 98, 1920, by laboratory experiments, has found an appreciable contraction with certain developers, no distortion with others. The following observations were made with the idea of reproducing more nearly the eclipse conditions.

Two pairs of plates of the Pleiades were obtained with a visual refractor of 30 cm aperture and 4.6 m focal length. Cramer Instantane-

ous Isochromatic plates and color filter were used. Two exposures of five minutes each were made on each plate. One plate of each pair was exposed to a circle of light, so that an image 31 mm in diameter and somewhat denser than the corona was printed on the center of the plate.

One pair of plates was developed with pyro and the other with hydroquinone. Fourteen faint stars, symmetrically arranged around the central image, were measured both in the x and y coördinates and the plates were compared by equations of the form

$$ax + by + c + E\,\alpha = x_1 - x_2,$$

where α is the distortion at the edge of the central disk and E is a coefficient obtained by assuming that the distortion is inversely proportional to the radial distance of the star from the edge of the disk. The results are as follows:

Plates A — B, developed with pyro.

From the x coördinates $\alpha = -.0016$ mm $\pm .0018$ mm
From the y coördinates $\alpha = -.0022$ mm $\pm .0014$ mm

Plates C — D, developed with hydroquinone.

From the x coördinates $\alpha = +.0035$ mm $\pm .0018$ mm
From the y coördinates $\alpha = -.0010$ mm $\pm .0019$ mm

On these plates 1 mm equals 43″, so in arc the above values become

$$\begin{aligned} \alpha &= -.069'' \pm .075'' \\ &= -.096'' \pm .061'' \\ &= +.150'' \pm .077'' \\ &= -.043'' \pm .082'' \end{aligned}$$

The values of α being of approximately the same order as the probable errors, it is evident that there is no photographic distortion, following the assumed law, large enough to be detected on these plates.

According to the Einstein theory $\alpha = +1''.75$ and the result obtained from the 1919 eclipse is $+1''.98$. From the above it appears that with ordinary developers the effects of photographic distortion, if they exist, must be very small in comparison with the results obtained from the eclipse plates.

FLEXURE OF DECLINATION CIRCLES.

By C. C. Smith and R. Meldrum Stewart.

The declination circles of the Troughton and Simms Meridian Circle in use at Ottawa are solid cast iron discs, 36 inches in diameter, one-half inch thick at the edge and one inch thick towards the centre. On determining the graduation errors of theses circles recently a quite appreciable difference between the mean of opposite microscopes at any position of the circle and the mean at a position 180° from this was apparent through the series of readings. After the elimination of any other cause for this it became apparent that the discrepancy arose

from irregular flexure of the circles due to non-homogeneity of the metal.

Two pairs of microscopes were used at varying angular distances apart and the graduation errors obtained from the differences of the means of the readings of opposite pairs. If the flexure of the circle were uniform no difference would appear in the measures for graduation errors at any one position and at a position 180° from this. When plotted, these differences formed a fairly well defined sine curve.

It is reasonable to assume that the flexure at any point on the circle varies as the sine of its zenith distance. If we assume also that it varies as the sine of its distance from some point on the circle we get the expression for the flexure of any division mark θ, when at zenith distance α

$$f_{\alpha\ \theta} = a \sin \alpha + b \sin \alpha \sin (\theta - \phi)$$

and for the flexure effect on the mean of the readings of two opposite microscopes

$$F_{\alpha\ \theta} = \tfrac{1}{2} (f_{\alpha\ \theta} + f_{\pi+\alpha\ \pi+\theta})$$

The flexure effect on another pair of microscopes, an angular distance ω from these, is

$$F_{\alpha-\omega\ \theta+\omega}$$

The differences of the means of the readings of two pairs of opposite microscopes is affected by the difference of the flexure on the two pairs.

This difference of flexure was used to find the factor b and the neutral point on the circle, denoted by ϕ. The expressions for the two circles A and B are respectively

$$F_{\alpha\ \theta} = 0''.14 \sin \alpha \sin (\theta - 238°\ 32')$$

$$F_{\alpha\ \theta} = 0''.24 \sin \alpha \sin (\theta - 148°\ 00')$$

The curve derived from the normal equations gives values for the difference of flexure with a probable error of $\pm 0''.085$. The weight of the computed factor b agrees very well with its theoretical weight but the values derived for the phase have less weight.

The quantity b may affect a zenith distance by its full value. The reversal of the circle in determining division errors eliminates it from these so that it is necessary to determine the flexure independently and apply it as an additional correction. The reversal of the eye and object ends of the telescope or the reversal of the circles, will, of course, also eliminate it.

ON SOME NEW VARIABLE STARS.

By Joel Stebbins.

65 τ Cygni, the spectroscopic binary of very short period, $3^h\ 25^m$, and described in another paper at this meeting by Paraskévopoulos, shows no variation and is presumably constant within a hundredth of a magnitude.

b Persei is a new ellipsoidal variable with continuous variation and a range of about 0.07 magnitude. There are some outstanding peculiarities which may possibly be established in the complete determination of the light-curve.

1 H. Cassiopeiae, previously announced, has been found to have an annular eclipse at primary minimum. The range at primary is 0.13 magnitude, at secondary 0.03 magnitude, and the light between minima is practically constant.

CHRONOGRAPHIC MEASUREMENT OF SMALL TIME INTERVALS.

By R. Meldrum Stewart.

It may be worth while to call attention to the fact that in many cases it is possible to measure small time-constants and related quantities without special apparatus such as is often used for the purpose, by the use of a printing chronograph.

If, for example, it be required to investigate the peculiarities of the individual beats of a clock, it is sufficient to allow the clock to record on the printing chronograph for, say, ten consecutive minutes; the differences between the means of individual seconds will give the quantities required; it may be remarked in passing that these systematic differences sometimes amount to several hundredths of a second, even in good clocks. The probable error of a single printed record, when read to the nearest hundredth of a second, is approximately .005 sec., so that the mean of ten will have a probable error of about .002 sec.; if greater accuracy is required more records may be made. In this particular case it is obviously necessary that the control of the chronograph should be effected by a pendulum contact, so that the accuracy of printing may be affected only by accidental error.

To measure the reaction-time of a relay a switch should be arranged so that the chronograph may be operated either directly by a clock (or by a relay controlled by it), or by the relay to be measured, the latter being actuated by the clock. Fifty clock beats printed with each arrangement suffice to determine the reaction-time to approximately .001 sec.; in this case, if the clock contact is not operated by the pendulum, the precaution should be taken of printing the same clock beats in each series, to eliminate the individuality of seconds referred to above.

It will be readily seen that similar methods may be used in any case where the operations to be measured can be repeated rythmically, by clock beats or otherwise. One of the advantages of the printing chronograph is the ease with which the records may be read, so that records may be multiplied without undue labor.

RECORDING OF WIRELESS TIME SIGNALS.

By R. Meldrum Stewart and J. P. Henderson.

The Dominion Observatory is equipped with a small aerial, several hundred feet in length, but at an average height of less than fifty feet. The receiving set in use consists of a set of honeycomb coils used in conjunction with four valves coupled by intervalve transformers, with the necessary apparatus for tuning to any wave-length. The standard method of receiving time signals has been the method of coincidences, the arrangement being a variation of that proposed by W. E. and F. B. Cooke (*Monthly Notices*, **77**, p. 469); it was more fully described at the last meeting in a paper by one of the present authors.

Some experimental work has been carried out on the chronographic registration of time signals, more especially with a view to investigation of the possible systematic errors involved; of this work the present paper is a preliminary report. Signals have been recorded on an ordinary chronograph through a relay (1) by inserting the relay directly in the plate circuit of the third or fourth bulb (2) by working the relay from a fairly delicate tungsten contact mounted on the diaphragm of a telephone receiver, the circuit through the relay being normally closed, but opened when the diaphragm is set in vibration by a signal. They have also been recorded directly on smoked paper by a stylus attached to the diaphragm of a telephone receiver.

In the relay methods the beats of the local sidereal clock were introduced through the aerial circuit by induction; two methods were experimented with; (1) an inductance in proximity to the primary tuning coil was connected in series with a battery and the points of the clock relay; the opening of the circuit by the relay induced a click in the telephones which was sufficient to operate the relay; (2) the inductance was connected in series with a high frequency buzzer and in multiple with the points of the clock relay, being thus short-circuited except at the instant of the clock beat. With the first arrangement there were found variations in relay time, between weak and strong clock beats, up to nearly .05 sec.; in the second case the greatest variation obtained was .009 sec. It appears to follow that clock signals introduced as isolated clicks are unsuitable, but that signals introduced by a buzzer are fairly satisfactory if reasonable care is exercised to obtain equivalent deflections in plate current for clock beats and incoming signals.

The smoked paper method was used to give a visible record of co-

incidences obtained as above, and also, by introducing sidereal clock beats, to give a record that could be scaled in the ordinary way.

Time signals have been recorded from Arlington, Annapolis, and Sayville; records have been obtained, frequently by several methods, on about seventy occasions during November and December. The method of coincidences was found to give the same result, whether observed in the telephones or read from the smoked paper; the two relay methods also agreed between themselves, but signals were on the average recorded earlier than by the coincidence method by .013 sec.; scalings from the smoked paper records gave an intermediate result. Should these results be confirmed it would follow that either (1) signals received by the coincidence method are effectively too late, or (2) the clock beats were in the other methods recorded relatively too late. Further investigation is required to settle these points.

PROGRESS IN THE REMEASUREMENT OF THE HUSSEY DOUBLE STARS.

By G. Van Biesbroeck.

Since 1917 the 40-inch refractor of the Yerkes Observatory has been used part of the time in re-observing the double stars that W. J. Hussey has discovered mostly at Mount Hamilton. In all he has announced 1650 new pairs, but about 300 of these, mostly found at La Plata, are too far south for this observatory. I have been limiting myself to stars north of —20°, which brings the total number of stars to be examined up to 1358. Out of these, measures have been completed (to December, 1920) on 421 pairs, but 752 pairs have been measured on one night at least, so that more than half of the stars have been looked up.

As was to be expected with double stars among which there is such a large percentage of close objects, motion has been detected in many pairs. In some 60 cases, or for about one star in twelve, a change of more than 10° in position angle or more than ½″ in distance could be established. These changes might seem small, but since the average interval of time covered by the measures is about 18 years, these displacements would correspond to fairly rapid motions. The following list includes stars for which the recent position depends on at least two nights: the coördinates are for 1900, the magnitudes are Hussey's; under s is given the distance measured recently; Δs and $\Delta\theta$ indicate the differences VB — Hu, and the last column the interval of time.

Hu	R. A.		Dec.		Magnitudes	s	Δs	$\Delta\theta$	Years
	h	m	°	′		″	″	°	
413	0	42	+22	42	8.0 - 9.2	0.74	—0.09	+ 10	18.2
1018	0	49	50	35	9.3 - 10.0	0.73	—0.07	+ 12	17.3
803	1	9	33	44	8.3 - 9.3	0.56	+0.06	+ 14	16.6
425	2	16	21	7	9.4 - 10.0	0.39	0.00	— 35	18.5
546	3	41	51	44	8.5 - 8.8	0.30	+0.06	—147	20.2
302	4	7	22	42	9.5 - 9.5	0.25	0.00	+ 14	18.6
304	4	18	9	14	5.9 - 5.9	0.31	+0.06	+ 24	18.9
608	4	20	35	31	8.4 - 8.8	0.35	—0.03	— 23	17.7
609	4	20	34	29	8.1 - 8.5	0.19	+0.02	— 47	17.7
1080	4	23	15	56	6.5 - 7.5	0.28	—0.16	—174	16.1
445	4	56	20	41	8.5 - 8.8	0.43	+0.02	+ 23	18.1
617	6	49	50	8	9.5 - 9.5	1.12	—0.01	+ 79	17.4
1124	8	12	49	45	8.0 - 12.1	2.91	—0.59	— 17	15.5
628	8	52	48	26	9.5 - 9.8	0.45	—0.48	— 5	17.3
1128	9	30	36	16	5.5 - 14.0	4.44	—1.41	— 2	14.3
879	10	22	37	13	4.0 - 6.5	Single	.....	.....	13-15
409	0	24	—14	58	8.9 - 9.5	0.72	+0.07	+ 10	18.6
575	14	38	19	55	9.0 - 9.5	0.49	—0.19	—140	18.2
481	16	17	23	14	7.3 - 9.2	0.61	+0.10	— 26	17.1
314	18	4	18	37	8.3 - 8.5	0.32	—0.03	— 10	19.0
197	18	15	10	14	8.2 - 9.3	0.33	—0.03	— 83	20.0
198	18	34	8	45	X Ophiuchi	0.22	0.00	— 24	20.2
767	21	9	15	34	7.0 - 7.0	0.18	+0.01	— 62	16.3
770	21	15	33	22	9.0 - 10.3	0.95	—0.06	+169	15.6
371	21	31	24	0	7.0 - 7.5	0.22	0.00	+ 23	17.7
280	21	37	5	27	7.7 - 8.1	0.19	0.00	+ 21	20.2
1320	22	29	48	52	8.2 - 8.2	0.31	+0.12	+ 44	15.8
494	22	36	6	0	8.8 - 9.0	0.31	0.00	+ 27	19.5
395	22	38	23	16	9.3 - 9.5	0.57	+0.08	— 14	18.1
290	22	41	+50	58	8.5 - 8.5	0.17	—0.01	+ 14	16.3
783	22	41	—16	6	9.0 - 11.0	5.72	+2.45	— 1	19.9
985	22	43	+12	27	8.8 - 9.8	0.59	—0.02	— 13	16.2
987	22	51	15	15	8.6 - 8.8	0.49	—0.16	— 23	15.6
992	22	57	+14	50	9.0 - 13.0	2.84	—0.04	— 13	14.6
398	22	57	18	4	8.7 - 9.0	0.42	—0.02	+ 18	19.2
994	23	4	+63	6	6.3 - 6.8	0.22	0.00	+ 14	15.3
295	23	17	—15	35	5.5 - 6.8	0.41	+0.04	+ 27	19.4

The following remarks should be added:

Hu 546: The large motion is confirmed by Hussey's second measure in 1902. Period less than 50 years.

Hu 1080: Period probably about 30 years. Hypothetical parallax 0″.04.

Hu 617: Rapid motion for a pair of this class. Period about 75 years. Hypothetical parallax 0″.06.

Hu 628: Makes an interesting triple system with ι Ursae Majoris.

Hu 1128: Physical pair with 0″.75 yearly proper motion.

Hu 575: Other observers confirm the change. Period less than 50 years. Hypothetical parallax 0″.04.

Hu 198: This is X Ophiuchi, long-period variable (P = 335 days) between the limits 6^m5 - 9^m0. This is the first star of such a late spectral type (Md 6 to Md 8) to show a fairly rapid orbital motion. Observations are continued for ascertaining which component is responsible for the change in brightness. (Or both?)

NOTE ON THE EFFECT OF THE BAROMETRIC GRADIENT ON MERIDIAN CIRCLE OBSERVATIONS.

By Charles Clayton Wylie.

The Washington observations of the Paris-Washington longitude campaign were investigated for anomalous refraction at the zenith due

to the barometric gradient. A least squares solution was made using the residuals for each night and the gradient scaled from the Weather Bureau map, but there was no evidence of the reality of the effect.

One hundred declination observations made at zenith distances over eighty degrees and furnished by Hammond of the U. S. Naval Observatory were then investigated in different ways. Where a north star was observed immediately after a south, or vice versa, the pair often showed evidence of a small effect which might be attributed to inclination of the layers of equal pressure. But the effect at extreme zenith distances is so small that, if really due to anomalous refraction, one could not hope to detect it at the altitudes at which accurate astronomical work is ordinarily attempted.

To get an idea of what might be expected in observing weather, the anomalous refraction at the zenith due to the barometric gradient of the Weather Bureau maps was computed for several nights on which astronomical observations were made. It was computed over Urbana for about forty nights on which photometric observations were made, and over Washington for about sixty nights on which transit observations were made. The maximum result was about one hundredth of a second of arc, an error too small for consideration in ordinary zenith telescope or meridian circle work.

By a similar computation carried through in reverse order, it was found that, to produce an error at the zenith equal to the night residuals of the Paris-Washington longitude work, the gradient of a tropical hurricane would be necessary.

We find then, by every method of attack, that the effect of the barometric gradient at moderate zenith distances must be exceedingly small; so small that observers need have no fear of its producing systematic errors in their routine work.

This is the result of other recent investigations. For example, Schlesinger with Blair and Hudson, Zimmer, and Comstock have all reached practically the above conclusion.

ON THE PROBABLE REASON WHY CERTAIN PERIODIC COMETS HAVE NOT BEEN FOUND ON THEIR PREDICTED RETURNS.

By Jessica M. Young.

Certain comets for which periodic orbits were derived have not been found again in spite of the fact that search ephemerides have been computed for expected returns. In some cases a satisfactory explanation has been made, while in others the failure to find the comet has remained unexplained. The orbits from which the ephemerides are computed are in general definitive orbits based upon a least squares reduction of normal places formed from all the available observations. The range of solution allowed in these ephemerides is in general very small, in some cases not more than two days. The question arises

whether perhaps the range of solution allowed for in the computation of the search ephemerides was not too short in the face of the uncertainties in the elements due to errors in the observations, limits in the length of the arc over which the comet was observed, and partial theoretical indeterminateness.

To investigate this question as regards errors in the observations Comets 1884 II (Barnard) and 1881 V (Denning) were chosen, because in neither case would the perturbations be appreciable. In each case three normal places covering as long an arc as possible were chosen for the basis of the computation. In order to furnish criteria for determining what variations could be allowed in the elements because of the inaccuracy of the observational material, the period of the best orbit available was varied arbitrarily and corresponding new orbits computed by Leuschner's method for a differential correction with the assumption of the period. The outstanding residuals were thrown into the first declination. A comparison of these residuals with the residuals allowable because of the uncertainty of the given observations gave the range allowable in the period. The ranges allowable in the first and third right ascensions and declinations were determined on the assumption that either of the limiting values of the observations used in the formation of a normal place might have been the correct value. The range of the residual allowable in the first declination, a function of the range in the first declination itself and also of that in the other coördinates, was then computed. By interpolation between the residuals found with the assumed periods the range of the period was determined. In this way it was found that the period of Comet 1884 II (Barnard) could lie anywhere between 5.3353 and 5.4792 years, a range of 52 days as compared with the range of 8 days allowed in the search ephemeris. In the case of Comet 1881 V (Denning) it was found that the period could lie anywhere between 8.747 and 9.038 years, a range of 106 days as compared with the range of 2 days used in the search ephemeris.

In the old orbits only the period was varied, but in this investigation the other elements were varied to correspond to the limiting values of the period. With these new elements (two sets for each comet) positions were computed for some date of the search ephemeris and the new area of search compared with the area of search allowed in the search ephemeris. Thus for Comet 1884 II (Barnard) the area of search, on August 28, 1900, would be according to the new range 35 times as great as that allowed by the search ephemeris. In the case of Comet 1881 V (Denning), on January 17, 1890, it would be about 280 times the area allowed by the original ephemeris. Therefore both of these comets may have been outside the region of search and the failure to find them was probably due to an altogether too limited range of the search ephemerides, the elements being considerably less accurate than the computers have supposed on the basis of their unnecessarily refined investigations.

THE SPECTROSCOPIC ORBIT OF o DRACONIS.

By R. K. Young.

o Draconis (R.A. 1900, $18^h\ 49.7^m$, Dec. 59° 16′) was announced as a spectroscopic binary from the Lick Observatory in 1910. Its spectral class is K and the lines are of very good quality. For a long time there has been need for more orbits of late type stars for statistical purposes. Thus of the two hundred orbits so far determined there are less than 30 of stars later than the F-type excluding the Cepheids. Almost all the observatories engaged in this line of work have been using one prism instruments and this dispersion has not been considered adapted for the late type stars on account of the small range which these stars usually show. The very satisfactory behavior of the one prism spectrograph attached to the 72-inch telescope and the small probable error obtained when the plates are measured on the Hartmann comparator, however, make it quite possible to obtain good approximate elements for many of these stars. Observations have been started on the stars listed below. Many of them give an indication of their period and the elements for o Draconis have been determined.

LIST OF STARS.

33 Piscium, ξ Piscium, δ Trianguli, τ Persei, ρ Orionis, 16 Aurigae, η Geminorum, Boss 2463, 12 Comae, 4 Ursae Minoris, BD 66°, 878, Boss 4129, Boss 4660, β Scuti, δ Sagittae, l Aquilae, μ Cephei, 24 Cephei.

In all only twelve observations of o Draconis were secured at Victoria and the four observations taken at the Lick Observatory since 1902 and the two observations at Bonn in 1911 supplement these in the most desirable way, enabling both the period and the shape of the curve to be determined. The final elements are

$$
\begin{aligned}
P &= 138.42 \text{ days} && \pm 0.016 \text{ day} \\
e &= 0.114 && \pm 0.014 \\
\omega &= 274^\circ.31 && \pm 6^\circ.36 \\
T &= \text{J.D. } 2{,}419{,}258.16 && \pm 2.43 \text{ days} \\
\gamma &= -19.52 \text{ km} && \pm 0.21 \text{ km} \\
K &= 23.46 \text{ km} && \pm 0.30 \text{ km} \\
a \sin i &= 28{,}030{,}000 \text{ km} \\
\frac{m_1^3 \sin^3 i}{(m + m_1)^2} &= 0.183\,\odot
\end{aligned}
$$

The probable error for a single observation taken at Victoria is 0.80 km, and if one observation be omitted for which the residual is abnormally large we obtain the low value 0.67 km. The probable errors attached to the elements show that they are fairly accurately determined.

THE POLE FINDER.

By WILLARD P. GERRISH.

A method by which the position of the celestial pole can be determined quickly, easily, and with moderate accuracy, finds a great variety of applications in the problems of astronomy and engineering. The device here described is simple and inexpensive, and affords a determination sufficiently accurate for making the preliminary adjustments of the polar axis of an equatorial telescope. Unless the telescope is to be used for work involving precise positions, this determination may in many instances be regarded as final.

The device, in its simplest form, consists of a pair of sights, front and rear, designed for observing Polaris. The front sight is a circular disc, graduated about its circumference to represent twenty four hours, and supported in a plane perpendicular to the line of sight. The rear sight is a piece containing a simple sighting hole about three millimetres in diameter. These are mounted upon a suitable base at a distance apart equal to about 25.6 times the diameter of the disc. With this proportion, the disc, when viewed through the hole of the rear sight, subtends an angle equal to that subtended by the circle traced by Polaris in its diurnal circuit around the Pole. It follows, therefore, that if the device is placed in a position so that Polaris, when seen through the rear sight, appears on the edge of the disc at a point corresponding to its hour angle, the line passing through the centres of the disc and the sighting hole also passes through the Pole. It is, of course, necessary that the graduations on the disc should have a known relation to the meridian in the position in which the device is used. An ordinary spur gear having twenty-four, or forty-eight, teeth makes an excellent disc, as its teeth are accurately cut, and are easily seen. The rear face of the disc should be white, and must be illuminated by light from a lantern, electric lamp, or other available source.

A convenient form of the apparatus consists of a combination of the sights with a straightedge parallel to the line passing through their centres. By means of the straightedge a line can be drawn on a pier, or other structure, after the necessary adjustment on the pole has been made. In many cases the sights may be attached directly to the instrument which they serve to adjust, due care being exercised to establish parallelism between their centres and the polar line of the instrument.

By suspending plumb-lines from the centres of the sights, the Pole Finder affords convenient means of determining the meridian for many purposes in which extreme accuracy is not required.

In a more accurate form of the device, a small telescope is provided with a reticule on which is drawn a circle graduated to correspond to twenty-four hours. The diameter of the circle should be to the focal

length of the telescope at 1 is to 25.65. When the telescope is adjusted so that Polaris appears at a point upon the circle corresponding to its hour angle, a cross at the centre of the circle indicates the position of the Pole.

Harvard College Observatory,
November 5, 1920.

THE MAKING OF A REFLECTOR BY AN AMATEUR.

By WM. M. BROWNE.

The average boy who takes to astronomy has neither the money nor the means to obtain a telescope of desirable dimensions, and is often discouraged when he inquires as to the price of such an instrument. But, like Herschel, he may if perseverant, construct a reflecting telescope of perhaps eight or ten inches aperture.

I am fourteen years old and am polishing a nine inch mirror. My greatest aid in this undertaking is the book by Dr. Henry Draper, entitled "On the Construction of a Silvered Glass Telescope Fifteen and One-half inches in Aperture, and its use in Celestial Photography." This book gives the particulars on grinding, polishing and testing mirrors.

The first articles needed in the construction of a mirror are two discs of glass of the proper diameter and about one and one-half inches thick in the case of an 8-inch or 10-inch disc. One of these discs need not be so thick as the other as the thin one will be used as the grinder.

If you can not procure discs of glass, get two square pieces large enough to cut the required discs out of. These discs may be cut out in a vertical drill press at some local machine shop if you promise the owner to clean up all the carborundum and leave the drill press as clean as you found it. You will, however, need the following equipment. On one side of the disc of wood about three-quarters of an inch thick and the diameter of the disc desired screw a spindle of some sort so that the wood can be rotated in the chuck of the drill. Around the edge screw a brass or iron band about three inches wide so that it projects about two and one-quarter inches out from the wood on the side opposite the spindle. See that the cutter that I have described runs true. Then saw several slits in the projecting edge of the band. Procure about two pounds of coarse carborundum and mix some of it with plenty of water in a small pan. Clamp the piece of glass on the table of the drill so that when the cutter is lowered on to the glass there is a border all around it. Start the drill and with a spoon feed the carborundum and water into the cut. Use a moderate pressure on the cutter and alternately raise and lower the cutter into the cut. If it tends to stick use more water and lessen the pressure. It took me about two hours to cut out a nine-inch disc which was one and one-half inches thick.

After you have your two discs cut out, visit several opticians and find one who will lend you a pair of iron grinders. They should be of 12 feet radius or a $+25$ and a -25 as they are often called by opticians.

The grinding table is a strong barrel with some bricks or earth in it for ballast. Set one of the discs on the top of the barrel and nail 3 or 4 cleats around it so that the disc will have no play but can easily be raised.

Make a pair of guages to test the curve to be ground in the glass. To do

this get a pole 12 feet long and pivot one end from a second story window and fasten a pencil at the other end and describe the curves on a piece of stiff cardboard. Cut out one convex and one concave guage of the same length as the diameter of the mirror.

Take the best or thickest disc and set it on the barrel. Put a spoonful of carborundum and water on the glass and take the convex grinder and go over the center of the disc with small circular strokes and at the same time walk slowly around the barrel. Renew the carborundum occasionally as it wears down and test the curve on the glass from time to time. As the excavation deepens extend the stroke over toward the edge until the curve extends to the edge. Do the same on the other disc with the concave tool starting on the edges and working toward the center.

When you have the curves roughed on the surfaces you must buy several pounds of sifted flour emery and wash it as described in Dr. Draper's book or buy the different grades.

Start with the coarsest grade and grind the two discs together until they touch all over and until the pits from the carborundum disappear. Then do the same with each successive grade taking care to eliminate pits and scratches with one grade before starting with the next.

When the last grade of emery is used the mirror is ready for polishing. Procure about 5 pounds of tar and a pound of rosin. Melt the tar in a can and add the rosin a little at a time until a drop in cold water will just dent with a moderate pressure of the fingernail. Then let the tar cool. While it is doing so warm the glass grinder and have the mirror on the barrel with some water on its surface. When the tar will just pour slowly, pour it on the center of the grinder and stop pouring when the tar comes within about an inch and one-half of the edge. Then tilt the glass in the hands so that the tar will run just to the edge. If it starts to run over, wet the fingers in cold water and press the tar back. Place your polisher, as it is now called, tar side down on the wet mirror and rub it over the mirror using pressure. When the tar fits the mirror, press grooves in the tar so that the surface is divided into one-inch squares. This can be done with a ruler, wetting the edge with cold water if it tends to stick to the tar. Then rub on the mirror to secure a fit again.

Procure about two pounds of rouge at an optician's and mix it with water in a jar. Stir well and let it settle for a few hours. Transfer the top one-third into a clean glass. This rouge is very fine and free from all grit and will give a fine polish to your mirror.

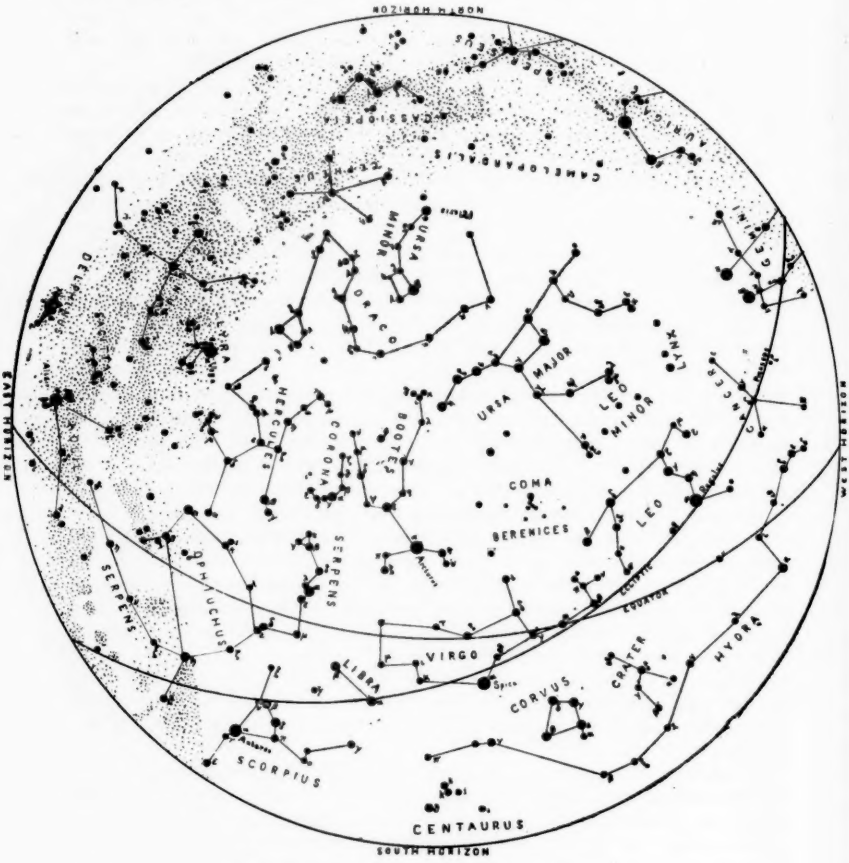
Now with the help of Dr. Draper's book start the polishing. After about 5 or 10 minutes polishing dry the surface and see if the gloss is all over the mirror, or more on one zone than another. If unequal, alter the stroke until it polishes evenly. As soon as the mirror will reflect light at all test it as described in Dr. Draper's book. Start right then to correct the surface if not spherical. Get a spherical surface in the beginning of the polishing and keep it so until the surface is fully polished. Then start the parabolizing, which is not very hard if done slowly and carefully.

I have not overcome the difficulties in getting a spherical surface myself, but I will sometime as I am anxious to complete my telescope. The above writing is taken from my own experience in this line of work and tells how I succeeded in getting this far with my mirror.

In my mind, the making of a mirror takes time and patience, but the accomplished result is so great in my estimation, that the effort to secure these results is many times repaid.

PLANET NOTES FOR JUNE, 1921.

The *Sun* enters Cancer on the 21st at 5:36 P.M. Central Standard Time, marking the beginning of summer.



THE CONSTELLATIONS AT 9:00 P. M. JUNE 1.

The phases of the *moon* will be as follows:

New Moon	June 6 at	0:14.7 A.M.	C.S.T.
First Quarter	12 "	2:59.5 P.M.	"
Full Moon	20 "	3:41.3 A.M.	"
Last Quarter	28 "	7:17.0 A.M.	"

Mercury reaches greatest eastern elongation on the 10th. At this time it will be 24° 13′ east of the sun and can be seen in the west after sunset. The planet will be in aphelion on the 27th.

Venus will be in conjunction with the moon on the 2nd, the planet being 1° 36′ south of our satellite. On the 23rd the planet will be in aphelion and reaches greatest western elongation July 1.

Mars will be too far from the earth and too near the sun for observation.

Jupiter, having just passed quadrature on the last of May will be in good position for early evening observation. The satellite phenomena will be found on another page.

Saturn reaches quadrature on the 9th, and like Jupiter, will be well placed for evening observation. The satellite phenomena will be found elsewhere in this issue. The sun and earth will be on opposite sides of the plane of the rings and the latter may be visible faintly.

Uranus will be in Aquarius during the month. On the morning of the 26th the planet will be in conjunction with the moon, being 4° 34′ south of the latter.

Neptune will be in Cancer but too near the sun for satisfactory observation.

Occultations Visible at Washington.

[*From the American Ephemeris.*]

Date 1921	Star's Name	Magnitude	IMMERSION. Washington M.T.	IMMERSION. Angle E from N	EMERSION. Washington M.T.	EMERSION. Angle E from N	Duration
			h m	°	h m	°	h m
June 16	ν Librae	5.3	8 57	96	10 23	298	1 27
16	22 Librae	6.5	9 23	144	10 34	250	1 11
18	81 B Ophiuchi	6.1	12 13	74	13 36	287	1 23
28	171 B Piscium	6.3	11 59	54	12 51	266	0 55

Phenomena of Jupiter's Satellites.

VISIBLE AT WASHINGTON.

[From the *American Ephemeris.*]

CENTRAL STANDARD TIME.

1921	d	h	m			1921	d	h	m		
June	2	9	35	III	Sh. E.	June	16	9	26	III	Tr. I.
		9	55	IV	Oc. D.		19	8	29	IV	Oc. R.
	4	8	6	II	Tr. I.		20	7	29	III	Ec. R.
		10	41	II	Sh. I.			8	24	II	Oc. D.
		10	57	II	Tr. E.		21	9	58	I	Oc. D.
	6	8	26	II	Ec. R.		22	7	19	I	Tr. I.
		8	57	I	Tr. I.			8	2	II	Sh. E.
		10	12	I	Sh. I.			8	30	I	Sh. I.
	7	9	37	I	Ec. R.			9	34	I	Tr. E.
	9	8	38	III	Tr. E.		23	7	57	I	Ec. R.
		10	31	III	Sh. I.		27	8	24	III	Ec. D.
	11	9	9	IV	Sh. E.		29	7	52	II	Sh. I.
	14	8	1	I	Oc. D.			8	21	II	Tr. E.
	15	7	37	I	Tr. E.			9	16	I	Tr. I.
		8	49	I	Sh. E.						

NOTE:—I. denotes ingress; E., egress; D., disappearance; R., reappearance; Ec., eclipse; Oc., occultation; Tr., transit of the satellite; Sh., transit of the shadow.

Saturn's Satellites.

Greatest elongations visible in the United States.
[From the *American Ephemeris.*]
CENTRAL STANDARD TIME.

I. Mimas. Period $0^d\ 22^h.6$.

1921	d	h		d	h		d	h		d	h	
June	3	13.6	W	June 11	13.9	E	June 16	7.0	E	June 23	8.7	W
	4	12.2	W	12	12.5	E	19	14.2	W	24	7.3	W
	5	10.8	W	13	11.2	E	20	12.8	W	29	11.7	E
	6	9.5	W	14	9.8	E	21	11.4	W	30	10.4	E
	7	8.1	W	15	8.4	E	22	10.1	W			

II. Enceladus. Period $1^d\ 8^h.9$.

June	1	15.6	E	June 9	20.9	E	June 18	2.3	E	June 24	22.7	E
	3	0.4	E	11	5.8	E	19	11.2	E	26	7.6	E
	4	9.3	E	12	14.7	E	20	20.0	E	27	16.5	E
	5	18.2	E	13	23.6	E	22	5.0	E	29	1.4	E
	7	3.1	E	15	8.5	E	23	13.8	E	30	10.3	E
	8	10.0	E	16	17.4	E						

III. Tethys. Period $1^d\ 21^h.3$.

June	1	8.7	E	June 8	21.9	E	June 16	11.2	E	June 24	0.5	E
	3	6.0	E	10	19.2	E	18	8.5	E	25	21.8	E
	5	3.3	E	12	16.6	E	20	5.9	E	27	19.2	E
	7	0.6	E	14	13.9	E	22	3.2	E	29	16.5	E

IV. Dione. Period $2^d\ 17^h.7$.

June	1	10.1	E	June 9	15.2	E	June 17	20.3	E	June 26	1.5	E
	4	3.8	E	12	8.9	E	20	14.0	E	28	19.2	E
	6	21.5	E	15	2.6	E	23	7.8	E			

V. Rhea. Period $4^d\ 12^h.5$.

June	5	2.3	E	June 14	3.2	E	June 23	4.2	E	June 27	16.7	E
	9	14.8	E	18	15.7	E						

VI. Titan. Period $15^d\ 23^h.3$.

June	7	12.9	E	June 15	8.7	E	June 23	12.3	E			

VII. Hyperion. Period $21^d\ 7^h.6$.

June	2	3.7	W	June 14	4.1	E	June 23	13.8	W			

VIII. Iapetus. Period $79^d\ 22^h.1$.

June 15 3.3 I

IX. Phoebe. Period $523^d\ 15^h.6$.

	α Ph.—α Sat.		δ Ph.—δ Sat.			α Ph.—α Sat.		δ Ph.—δ Sat.	
	m	s	′	″		m	s	′	″
June 2	+1	37.1	—11	29	June 16	+1	34.9	—10	56
4	1	37.1	11	26	18	1	34.2	10	49
6	1	37.0	11	22	20	1	33.4	10	41
8	1	36.7	11	18	22	1	32.5	10	33
10	1	36.4	11	13	24	1	31.6	10	24
12	1	36.0	11	8	26	1	30.6	10	15
14	+1	35.5	—11	2	28	1	29.5	10	5
					30	+1	28.3	— 9	54

NOTE:—E, Eastern Elongation; I, Inferior Conjunction (south of planet); W, Western Elongation; S, Superior Conjunction (north of planet).

VARIABLE STARS.

Minima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1921 June							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8					17 4			
RT Sculptor.	31.5	—26 13	9.6—10.5	0 12.3	3 23	11 15	19 7	26 23				
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	3 19	11 5	18 16	26 2				
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	4 3	11 14	19 2	26 13				
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	2 23	9 1	21 7	27 9				
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	6 7	13 11	20 14	27 18				
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	1 19	8 15	22 9	29 6				
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	3 0	10 5	17 9	24 13				
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	4 9	13 4	21 22	30 17				
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	8 11	16 10	24 9					
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6	2 4							
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	2 13	8 6	19 18	25 11				
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	2 13	9 8	22 22	29 18				
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	1 22	9 20	17 17	25 15				
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	8 18	17 1	25 9					
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	3 23	11 20	19 18	27 15				
RW Persei	13.3	+42 04	8.8—11.0	13 04.8	1 16	14 20	28 1					
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	4 9	13 20	23 6					
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1		12 16	25 2					
TT Aurigæ	5 02.8	+39 27	7.8— 8.7	0 16.0	3 5	9 20	23 4	29 20				
RY Aurigæ	11.5	+38 13	10.7—11.7	2 17.5	3 0	11 5	19 9	27 13				
RZ Aurigæ	42.9	+31 40	10.6—13.3	3 00.3	4 8	10 8	22 9	28 10				
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	2 18	11 11	20 3	28 19				
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	3 3	13 13	23 23					
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	4 18	12 19	20 19	28 19				
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	3 12	9 5	20 16	26 10				
U Columbæ	6 11.2	—33 03	9.2—10.0	2 19.2	6 0	11 15	22 15	28 10				
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	1 6	9 11	17 16	25 20				
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	1 7	8 22	16 23	24 4				
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0		12 8	24 13					
RU Monoc.	6 49.4	— 7 28	9.8—10.5	0 21.5	7 23	15 3	22 7	29 11				
R Can. Maj.	7 14.9	—16 12	5.8— 6.4	1 03.3	5 6	12 1	18 21	25 17				
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	1 7	10 14	19 21	29 5				
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	3 18	10 8	23 13	30 4				
TX Gemin.	30.3	+17 08	10.0—11.9	2 19.2	6 5	14 15	23 0					
RR Puppis	43.5	—41 08	9.4—10.7	6 10.3	6 8	12 18	19 5	25 15				
V Puppis	7 55.4	—48 58	4.1— 4.8	1 10.9	5 7	12 13	19 20	27 2				
X Carinae	8 29.1	—58 53	7.9— 8.7	0 13.0	7 14	15 16	23 20					
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	2 15	12 2	21 14					
RX Hydræ	9 00.8	— 7 52	9.1—10.5	2 6.8	4 1	10 21	17 17	24 14				
S Velorum	29.4	—44 46	7.8— 9.3	5 22.4	6 13	12 11	24 8	30 7				
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	1 23	8 16	22 4	28 22				
RR Velorum	10 17.8	—41 36	10.0—10.9	1 20.5	2 2	9 12	16 22	24 8				
SS Carinæ	10 54.2	—61 23	12.2—12.8	3 07.2	7 3	13 17	20 7	26 22				
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	8 0	16 20	25 15					
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	1 1	8 9	23 1	30 8				
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	6 18	13 13	20 8	27 3				
RZ Centauri	12 55.6	—64 05	8.5— 8.9	1 21.0	1 17	9 5	16 17	24 5				
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.1	8 13	18 4	27 18					
SS Centauri	07.2	—63 37	8.8—10.4	2 11.5	6 12	13 23	21 9	28 19				
133926 Hydræ	13 39.0	—26 23	8.6—12.7	2 21.5	5 12	11 8	22 22	28 17				

Minima of Variable Stars of Short Period—Continued.

Star	R.A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of minima in 1921 June							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
δ Libræ	14	55.6	— 8	07	4.8— 6.2	2	07.9	4	8	11	8	18	7	25	7
U Coronæ	15	14.1	+32	01	7.6— 8.7	3	10.9	3	14	10	12	17	10	24	7
TW Draconis	15	32.4	+64	14	7.3— 8.9	2	19.3	5	20	14	6	22	16		
SS Librae	15	43.4	—15	14	9.3—11.5	0	18.4	6	0	13	16	21	7	28	23
SW Ophiuchi	16	11.1	— 6	44	9.2—10.0	2	10.7	4	3	11	11	18	19	26	3
SX Ophiuchi		12.6	— 6	25	10.5—11.2	2	01:5	2	16	10	22	19	5	27	11
R Aræ		31.1	—56	48	6.8— 7.9	4	10.2	7	21	16	17	25	14		
TT Herculis	16	49.9	+17	00	8.9— 9.3	20	18.1	2	19	13	20	23	13		
TU Herculis	17	09.8	+30	50	9.5—12	2	06.4	1	0	7	19	21	9	28	5
U Ophiuchi		11.5	+ 1	19	6.0— 6.7	0	20.1	1	9	9	18	18	3	26	13
μ Herculis		13.6	+33	12	4.6— 5.4	2	01.2	6	10	12	13	18	17	24	2
TX Herculis		15.4	+42	00	8.3— 9.0	1	00.7	5	0	11	4	23	13	29	17
RV Ophiuchi		29.8	+ 7	19	9. —12	3	16.5	6	0	13	9	20	18	28	3
SZ Herculis		36.0	+33	01	9.5—10.3	0	19.6	6	11	14	15	22	20		
TX Scorpii		48.6	—34	13	7.5— 8.2	0	22.6	3	15	11	4	18	17	26	6
UX Herculis		49.7	+16	57	8.8—10.5	1	13.2	3	0	10	18	18	12	26	6
Z Herculis		53.6	+15	09	7.1— 7.9	3	23.8	7	16	15	15	23	15		
WX Sagittarii		53.6	—17	24	9.2—10.8	2	03.1	2	19	11	7	19	20	28	8
WY Sagittarii	17	54.9	—23	1	9.5—10.6	4	16.0	1	16	11	0	20	8	29	16
SX Draconis	18	03.0	+58	23	9.3—10.5	5	04.1	8	18	19	2	29	10		
RS Sagittarii		11.0	—34	08	5.9— 6.3	2	10.0	6	13	13	19	21	1	28	7
V Serpentis		11.1	—15	34	9.5—11.1	3	10.9	1	17	8	15	22	10	29	8
RZ Scuti		21.1	— 9	15	7.4— 8.3	15	03.2	6	9			21	12		
RZ Draconis		21.8	+58	50	9.5—10.2	0	13.2	6	3	13	7	20	11	27	15
RX Herculis		26.0	+12	32	7.0— 7.6	0	21.3	6	14	13	17	20	20	27	23
SX Sagittarii		39.7	—30	36	8.7— 9.8	2	01.8	8	22	17	6	25	13		
RR Draconis		40.8	+62	34	9.3—13	2	19.9	3	13	12	1	20	12	30	0
RS Scuti		43.7	—10	21	9.3—10.3	0	15.9	4	4	10	20	24	3	30	18
β Lyræ		46.4	+33	15	3.4— 4.1	12	21.8	3	18	16	16	29	14		
U Scuti	18	48.9	—12	44	9.1— 9.6	0	22.9	1	14	9	6	16	21	24	12
RX Draconis	19	01.1	+58	35	9.3—10.2	1	21.4	3	23	11	12	19	2	26	16
RV Lyræ		12.5	+32	15	11. —12.8	3	14.4	9	0	15	5	22	10	29	15
RS Vulpec.		13.4	+22	16	6.9— 8.0	4	11.4	3	21	12	20	21	19	30	18
U Sagittæ		14.4	+19	26	6.5— 9.0	3	09.1	2	15	9	9	22	22	29	16
Z Vulpec.		17.5	+25	23	7.3— 8.5	2	10.9	5	18	13	3	20	12	27	20
TT Lyræ		24.3	+41	30	9.4—11.6	5	05.8	1	15	12	2	22	14	27	20
UZ Draconis		26.1	+68	44	9.0— 9.8	1	15.1	7	0	12	13	19	1	25	14
SY Cygni	19	42.7	+32	28	10 —12	6	00.2	2	12	8	12	20	12	26	12
WW Cygni	20	00.6	+41	18	9.3—13.4	3	07.6	2	17	9	8	22	15	29	6
SW Cygni		03.8	+46	01	9. —11.7	4	13.8	8	3	17	6	26	10		
VW Cygni		11.4	+34	12	9.8—11.8	8	10.3	7	10	15	20	24	6		
RW Capric.		12.2	—17	59	8.8—10.6	3	09.4	4	18	11	13	18	8	25	2
UW Cygni		19.6	+42	55	10.5—13	3	10.8	3	5	10	2	23	21	30	19
V Vulpec.		32.3	+26	15	8.2— 9.8	37	19.0								
W Delphini		33.1	+17	56	9.4—12.1	4	19.4	9	12	19	3	28	18		
RR Delphini		38.9	+13	35	10.5—11.8	4	14.4	1	12	10	17	19	21	29	2
Y Cygni		48.1	+34	17	7.1— 7.9	1	12.0	8	4	15	16	23	4	30	15
WZ Cygni		49.3	+38	27	9.9—10.8	0	14.0	1	0	8	15	16	5	23	19
RR Vulpec.	20	50.5	+27	32	9.6—11.0	5	01.2	1	20	11	23	21	1		
VVCygni	21	02.3	+45	23	12.1—13.8	1	11.4	5	11	12	20	20	5	27	14
AE Cygni		09.0	+30	20	10.8—11.4	0	23.3	6	8	16	1	25	18		
RY Aquarii		14.8	—11	14	8.8—10.4	1	23.2	7	10	15	7	23	4		
RT Lacertæ	21	57.4	+43	24	9.1—10.5	5	01.7	2	10	12	13	22	17		
UZ Cygni		55.2	+43	52	8.9—11.6	31	07.3	8	18						
RW Lacertæ	22	40.6	+49	08	10.2—11.2	5	04.4	5	18	10	23	21	8	26	12
8.1914 Pegasi		51.7	+32	41	10.0—10.6	5	06.4	5	10	10	16	21	5	26	12
TT Androm.	23	08.7	+45	36	11.3—12.6	2	18.4	7	0	15	8	23	15		
Y Piscium		29.3	+ 7	22	9.0—12.0	3	18.3	7	1	14	14	22	3	30	16
TW Androm.	23	58.2	+32	17	8.6—11.5	4	02.9	9	5	17	11	25	16		

Maxima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of maxima in 1921							
								June							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
SX Cassiop.	0	05.5	+54	20	8.6— 9.2	36	13.7	7	21						
SY Cassiop.	0	09.8	+57	52	9.3— 9.9	4	1.7	3	7	11	10	19	13	27	16
RR Ceti	1	27.0	+ 0	50	8.3— 9.0	0	13.3	1	19	9	13	17	7	24	1
RW Cassiop.	1	30.7	+57	15	8.9—11.0	14	19.2			8	7	23	3		
V Arietis	2	09.6	+11	46	8.3— 9.0	0	23.8	5	10	13	9	21	7	29	6
SU Cassiop.	2	43.0	+68	28	6.5— 7.0	1	22.8	1	13	8	18	16	13	24	8
TU Persei	3	01.8	+52	49	11.4—12.2	0	14.6	6	9	13	16	20	23	28	6
RW Camelop.	3	46.2	+58	21	8.2— 9.4	16	00.0			10		26			
SX Persei	4	10.2	+41	27	10.4—11.2	4	07.0	6	17	15	7	23	21		
SV Persei		42.8	+42	07	8.8— 9.6	11	03.1	9	1			20	4		
RX Aurigæ	4	54.5	+39	49	7.2— 8.1	11	15.0	8	19			20	10		
SX Aurigæ	5	04.6	+42	02	8.0— 8.7	1	12.8	6	4	13	19	21	11	29	3
SY Aurigæ		05.5	+42	41	8.4— 9.5	10	03.3	10	5	20	9	30	12		
Y Aurigae		21.5	+42	21	8.6— 9.6	3	20.6	5	5	12	22	20	15	28	8
RZ Gemin.	5	56.6	+22	15	9.1—10.0	5	12.7	6	11	11	23	23	1	28	14
RS Orionis	6	16.5	+14	44	8.2— 8.9	7	13.6	3	20	11	9	18	23	26	12
T Monoc.		19.8	+ 7	08	5.7— 6.8	27	00.3	1	14					28	15
RT Aurigæ		23.0	+30	33	5.1— 6.0	3	17.5	6	13	14	1	21	11	28	23
RZ Camelop.		23.7	+67	06	11.0—13.0	0	11.5	6	5	13	10	20	15	27	20
W Gemin.		29.2	+15	24	6.7— 7.5	7	22.0	3	17	11	15	19	13	27	11
ζ Gemin.	6	58.2	+20	43	3.7— 4.3	10	03.7	4	12	14	16	24	19		
RU Camelop.	7	10.9	+69	51	8.5— 9.8	22	06.5			12	11				
RR Gemin.	7	15.2	+31	04	10.0—11.5	0	09.5	5	4	13	3	21	1	28	23
V Carinæ	8	26.7	—59	47	7.4— 8.1	6	16.7	5	16	12	9	19	1	25	18
T Velorum	8	34.4	—47	01	7.6— 8.5	4	15.3	3	12	12	18	22	1		
V Velorum	9	19.2	—55	32	7.5— 8.2	4	08.9	4	13	13	7	22	1	30	19
Z Leonis	9	46.4	+27	22	7.9— 9.6	59	00.0								
RR Leonis	10	02.1	+24	29	9.1—10.1	0	10.9	4	8	11	3	17	22	24	17
SU Draconis	11	32.2	+67	53	8.9— 9.6	0	15.8	6	8	12	22	19	13	26	3
S Muscæ	12	07.4	—69	36	6.4— 7.3	9	15.8			10	9	20	0	29	16
SW Draconis		12.8	+70	04	8.8— 9.6	0	13.7	6	20	14	19	22	18		
T Crucis		15.9	—61	44	6.8— 7.6	6	17.6	3	10	10	3	16	21	23	14
R Crucis		18.1	—61	04	6.8— 7.9	5	19.8	3	8	9	4	20	20	26	15
S Crucis	12	48.4	—57	53	6.5— 7.6	4	16.6	3	23	8	16	18	1	27	10
W Virginis	13	20.9	— 2	52	8.7—10.4	17	06.5	5	9			22	15		
SS Hydræ		25.0	—23	08	7.4— 8.1	8	04.8	7	5	15	10	23	14		
RV Urs. Maj.	13	29.4	+54	31	9.2— 9.9	0	11.2	5	6	12	7	19	7	26	8
ST Virginis	14	22.5	— 0	27	10.3—11.4	0	09.9	7	8	15	13	23	18		
V Centauri		25.4	—56	27	6.4— 7.8	5	11.9	2	10	7	21	18	21	24	9
RS Bootis		29.3	+32	11	8.9—10.0	0	09.1	4	23	12	12	20	1	27	14
RU Bootis	14	41.5	+23	44	12.8—14.3	0	11.9	6	12	13	22	21	8	28	17
R Triang. Austr.	15	10.8	—66	08	6.7— 7.4	3	09.3	3	4	9	22	23	12	30	6
S Triang. Austr.	15	52.2	—63	29	6.4— 7.4	6	07.8	4	2	10	10	23	1	29	9
S Normæ	16	10.6	—57	39	6.6— 7.6	9	18.1	9	23	19	17	29	11		
RW Draconis		33.7	+58	03	9.6—10.8	0	10.6	5	13	14	10	23	7		
RV Scorpii	16	51.8	—33	27	6.7— 7.4	6	01.5	5	7	11	8	23	11	29	13
X Sagittarii	17	41.3	—27	48	4.4— 5.0	7	00.3	4	3	11	4	18	4	25	4
Y Ophiuchi		47.3	— 6	07	6.1— 6.5	17	02.9			12	2			29	5
W Sagittarii	17	58.6	—29	35	4.3— 5.1	7	14.3	5	1	12	15	20	5	27	20
Y Sagittarii	18	15.5	—18	54	5.4— 6.2	5	18.6	6	17	12	12	24	1	29	19
U Sagittarii		26.0	—19	12	6.5— 7.3	6	17.9	5	15	12	8	19	2	25	20
Y Scuti		32.6	— 8	27	8.7— 9.2	10	08.3	5	5	15	14	25	22		
Y Lyræ		34.2	+43	52	11.3—12.3	0	12.1	1	5	7	5	19	7	25	8
RZ Lyræ	18	39.9	+32	42	9.9—11.2	0	12.3	2	3	8	6	20	12	26	16

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1921 June							
	h m	° ′		d h	d	h	d	h	d	h	d	h
RT Scuti	18 44.1	−10 30	9.1— 9.7	0 11.9	3	2	9	1	20	22	26	21
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	7	2	16	4	25	7		
U Aquilæ	19 24.0	— 7 15	6.2— 6.9	7 00.6	7	11	14	12	21	12	28	13
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	7	17	14	17	21	17	28	17
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	1	15	9	14	17	14	25	13
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	6	18	14	11	22	3	29	20
η Aquilæ	47.4	+ 0 45	3.7— 4.5	7 04.2	2	6	9	10	16	14	23	19
S Sagittæ	51.5	+16 22	5.6— 6.4	8 09.2	5	11	13	20	22	5		
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	6	21	13	4	19	12	25	20
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3			15	15				
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	4	2	8	13	17	10	26	7
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	3	5	9	23	23	10	30	3
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	5	3	11	20	18	13	25	6
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	3	23			18	17		
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	5	23	13	20	21	17	29	13
SW Aquarii	10.2	— 0 20	9.9—10.8	0 11.0	7	18	14	16	21	13	28	10
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	4	1	8	22	18	15	28	9
Y Lacertæ	22 05.2	+50 33	9.1— 9.6	4 07.8	8	12	17	3	25	19		
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	1	12	12	6	17	14	28	8
Z Lacertæ	36.9	+56 18	8.2— 9.0	10 21.1	8	5	19	2	29	23		
RR Lacertæ	37.5	+55 55	8.5— 9.2	6 10.1	3	0	9	10	22	6	28	16
V Lacertae	44.5	+55 48	8.5— 9.5	4 23.6	5	3	10	2	20	2	25	1
X Lacertæ	22 45.0	+55 54	8.2— 8.6	5 10.7	2	0	7	10	18	8	29	5
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	5	15	11	2	21	23	27	10
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	1	8	7	15	20	6	26	13
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	2	6	14	10	26	13		
V Cephei	23 51.7	+82 38	6.0— 7.0	0 23.9	2	20	9	19	23	18	30	18

COMET AND ASTEROID NOTES.

Winnecke's Comet Found by Barnard.—The comet referred to on page 236 of the April issue of POPULAR ASTRONOMY as the Pons-Winnecke Comet has been rediscovered by Professor E. E. Barnard at the Yerkes Observatory. The comet was found on a photographic plate and its position first given was

April 10.8868 G.M.T., R.A. $15^h\ 54^m\ 38^s$, Dec. $+36°\ 38'$.

It was described as being visible in large telescope.

On April 12 the comet was again observed by the Astronomer Royal, Dr. Dyson at the Greenwich Observatory as follows:

April 12.4677 G.M.T., R.A. $15^h\ 58^m\ 07^s.9$, Dec. $+37°\ 15'\ 47''$.

Magnitude 12.

Other observations have been reported as follows:

G.M.T.	R.A. h m s	Dec. ° ′ ″	Observer	Place
April 12.6458	15 58 31.9	+37 19 59	Barnard	Yerkes Observatory
12.6814	15 58 36.7	+37 20 49	Barnard	Yerkes Observatory
12.9761	15 59 15.7	+37 28 27	Gallo	Tacubaya
17.6793	16 10 28.65	+39 13 51.9	Van Biesbroeck	Yerkes Observatory

Reid's Comet.—In addition to the positions of Reid's Comet given on page 237 of the April issue the following position of this comet has been received through the H. C. O. Bulletin 747:

G. M. T.	R. A. h m s	Dec. ° ′ ″	Observer	Place
March 28.9227	20 22 40.7	−9 19 14.3	Van Biesbroeck.	Yerkes Observatory

H. C. O. Bulletin 748 announces the following sets of elements of this comet, the former by Professor Van Biesbroeck, Yerkes Observatory, from observations on March 14, 15, and April 4; the latter by Messrs. Einarsson and Meyer, Students' Observatory, University of California, from observations on March 14, 25, and 28.

T	= 1921, May 8.9660 G.M.T.	1921, May 10.00 G.M.T.
ω	= 65° 8′	64° 15′
Ω	= 269° 50′	268° 23′
i	= 134° 38′	131° 57′
q	= 0.988	1.013

A letter from Professor W. J. Hussey of the Detroit Observatory of the University of Michigan contains the following notes on this comet:

The following elements for Reid's Comet have been computed by Mr. Rossiter of this observatory from observations of March 14, 18, and 25.

Time of perihelion passage	(T)	= 1921 May 10.1332	
Longitude of perihelion	(π)	= 332° 55′.2	} 1921.0
Longitude of node	(Ω)	= 268° 23′.8	
Inclination	(i)	= 131° 55′.3	
Perihelion distance	(q)	1.0101	

The comet is at present about the 6.5 magnitude. Its declination rate has changed from about one degree a day to three degrees and in the week previous to perihelion passage will reach a rate of about 4 degrees a day. After April 28 it will become circumpolar and barely visible to the naked eye. It reaches its nearest approach to the earth at about that date.

The accompanying photograph was taken by Mr. McLaughlin of this ob-

servatory about 4 A. M., April 19. The exposure was 35 minutes in length and was taken with the three-inch finder of the 12-inch refractor. The photograph has been enlarged 1.8 times.

The following observations have been made with the 12-inch refractor by the method of direct micrometer measurements.

G. M. T. 1921		Apparent α h	m	s	Apparent δ °	′	″	Observer
April	2.8954	20	25	30.3	—4	34	18	McLaughlin
	2.9146	20	25	31.9	—4	33	16	Rossiter
	4.8892	20	26	40.9	—2	18	48	McLaughlin
	6.9238	20	27	54.1	+0	24	28	Rossiter
	10.8972	20	30	31.6	+6	12	55	McLaughlin
	10.9110	20	30	34.3	+6	14	16	Rossiter
	17.9082	20	36	19.3	+20	45	44	Rossiter
	18.8552	20	37	18.5	+23	12	50	McLaughlin
	18.8700	20	37	20.3	+23	15	8	Rossiter

Note Concerning Wolf's Periodic Comet.—I have the honour to announce hereby, that in connection with my statement in the "Astronomische Nachrichten" No. 4252, (Vol. 176, No. 4, p. 71-72), I am continuing now my researches and calculations, concerning the theory of Wolf's Comet.

These computations have been interrupted for some period, as I was pressed to leave Vladivostock and Vladivostock Naval Observatory, founded by me in 1919; the reason is, that the entrance of the bolsheviki into Vladivostock, at the beginning of 1920, was very dangerous for the freedom of my residence there.

The necessity of earning a living does not give me the possibility to spend as much time as it would be desirable for computations of the comet's motion; nevertheless, I have already prepared 5 or 6 articles, containing the perturbations and the theory of the comet during 1884-1919, for printing.

At some time I hope to finish my researches and to present a complete theory of Wolf's Comet during 1884-1919, also the results of its approach to Jupiter in 1922. However, it is now evident, that all the six returns of the comet to the sun, namely in

1884-1885, 1891-1892, 1898-1899, (1904-1905), 1911-1912, 1918-1919,

may be represented by *one* system of the elements with relatively small residuals (when taking into consideration the perturbations caused by Venus, Earth, Mars, Jupiter and Saturn).

M. KAMENSKY, *Astronomer.*

Tokyo, Japan, 18th March, 1921.

Asteroid Discovered. —A cabelgram from M. Lecointe, at Uccle (Bruxelles), announces the discovery of a minor planet of 12th magnitude by Reinmuth, of Koenigstuhl, Germany, in the following position:

April 1.4395 G. M. T.
R. A. $12^h\ 59^m\ 56^s$
Dec. $+3°\ 19'$
Daily motion, 40ˢ west, 23′ north.

S. I. BAILEY.

Harvard College Observatory Bulletin 747.

Ephemeris of the Jovian Asteroid (588) Achilles.—The ephemeris here given was computed with the System of Elements III of the Copenhagen Observatory Publication No. 29 and with the aid of a continued computation of perturbations.

1921 Gr. Mid.		R. A. h m s	Dec. ° ′ ″	Log Δ
May	2	15 21 44	—31 8.6	0.6926
	6	19 35	31 2.8	
	10	17 25	30 56.1	0.6910
	14	15 14	30 48.4	
	18	13 4	30 39.9	0.6910
	22	10 57	30 30.8	
	26	8 53	30 21.0	0.6927
	30	6 54	30 10.6	
June	3	5 1	29 59.9	0.6960
	7	3 16	29 48.9	
	11	1 38	29 37.8	0.7007
	15	15 0 10	29 26.6	
	19	14 58 51	29 15.5	0.7068
	23	57 43	29 4.6	
	27	56 45	28 54.0	0.7141
July	1	55 58	28 43.8	
	5	55 23	28 34.0	0.7222
	9	54 59	28 24.8	
	13	14 54 47	—28 16.2	0.7310

Opposition 1921 May 11. Magnitude $15^{m}0$.

JULIE M. VINTER HANSEN.

University Observatory, Copenhagen, 1921 February 15.

Monthly Report of the American Association of Variable Star Observers, February 20 to March 20, 1921.

The most interesting feature of the current report is the sudden minimum of R Coronae Borealis, 154428. This star has been almost constant at maximum since the spring of 1917. The present drop was very well observed, being noted independently by several observers, although complete reports especially from overseas members are not yet available. The star is rising again, but of course predictions with regard to what it will do are notoriously unreliable. U Geminorum, 074922, rose to maximum on March 16, close to the predicted date. SS Cygni is becoming more easily available now.

Mr. Theodore Dunham, Jr., who is at present engaged in research at Harvard University, has been recently elected to active membership, and a contribution from him is included in this report, as are also reports from the following members who have joined recently: Messrs Chandler, Kanda, and Leavenworth, and Miss Clough. Messrs Peltier and Ginori are to be especially commended for valuable lists this month.

It is planned to have the spring meeting on May 28, and through the kindness of Miss Furness this is to be held at Vassar College Observatory.

In order to secure as satisfactory a form as possible for the report an additional change has been adopted which will be noted in this month's issue. This consists in printing the full name of the star on a separate line, thus allowing more space for the observations which appear below it. This permits a return to the traditional symbol (<) for negative, i. e., "not seen", observations, in place of the italics which have been in use in these reports for almost a year.

Attention is again called to the fact that hereafter all observations should be sent in duplicate to the A. A. V. S. O., Harvard College Observatory, Cambridge 38, Mass., U. S. A.

The following observers contributed to this report: Messrs Barns, "Bs," Bouton, "B," Chandler, "Cd," Chandra, "Ch," Miss Clough, "Cg." Dunham, "Du,"

VARIABLE STAR OBSERVATIONS, February 20 to March 20, 1921.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.
001726 T ANDROMEDAE—								
	2697.1	9.8 Ch,	2704.1	9.5 Ch,	2715.1	8.5 Ch,	2751.6	8.8 Pt.
001755 T CASSIOPEIAE—								
	2694.5	8.7 Gi,	2709.3	8.6 Gi,	2721.0	8.2 Jk,	2725.4	7.9 L,
	2725.4	8.3 Gi,	2738.3	8.1 Gi,	2739.8	7.6 Bs,	2744.3	8.2 L,
	2751.6	7.8 Pt,	2759.6	8.2 Ya.				
001838 R ANDROMEDAE—								
	2691.4	7.0 El,	2697.1	9.1 Ch,	2703.3	6.8 El,	2724.3	9.4 Ja,
	2725.6	9.7 Jd,	2726.7	9.5 Jd,	2727.5	9.6 Cd,	2736.3	9.5 Pe,
	2740.5	9.7 Cd,	2745.2	9.7 Pe,	2745.5	9.8 Cd,	2751.6	9.9 Pt,
	2762.5	10.5 Cd.						
001909 S CETI—								
	2691.1	11.5 Ch,	2715.0	10.3 Ch,	2734.2	9.7 L.		
004047 U CASSIOPEIAE—								
	2746.5	10.2 Y,	2751.6	10.3 Pt.				
004746 RV CASSIOPEIAE—								
	2758.6	9.5 Pt.						
004958 W CASSIOPEIAE—								
	2699.4	8.4 Gi,	2717.4	8.6 Gi,	2736.3	8.6 Gi,	2745.5<	9.5 Cg,
	2751.6	9.2 Pt,	2759.5<	9.5 Cg.				
011272 S CASSIOPEIAE—								
	2721.4<12.6 Rk,		2733.4<12.6 Rk,		2740.4<10.8 Rk,			
	2745.4<12.6 Rk,		2747.4<12.6 Rk,		2747.6<13.0 Lv.			
012350 RZ PERSEI—								
	2746.5	10.3 Y.						
013238 RU ANDROMEDAE—								
	2704.2	10.2 Ch.						
013338 Y ANDROMEDAE—								
	2692.2<11.0 Ch,		2746.5	9.4 B,	2751.6	8.6 Pt.		
014958 X CASSIOPEIAE—								
	2746.5	10.2 Y,	2751.6	11.3 Pt.				
015354 U PERSEI—								
	2735.6	9.6 Pw,	2751.6	8.2 Pt.				
021024 R ARIETIS—								
	2699.3	12.9 Gi,	2717.3	13.5 Gi,	2726.7<10.6 Jd,		2730.3	13.2 Gi,
	2745.6	12.6 B,	2746.3	12.5 Gi,	2747.3	12.1 L,	2751.6	11.6 Pt,
021143 W ANDROMEDAE—								
	2694.5	12.2 Gi,	2715.4	12.7 Gi,	2734.4	13.0 Gi,	2746.4	13.2 Gi.
021403 o CETI—								
	2697.1	9.3 Ch,	2716.1	9.5 Ch,	2725.3	9.4 Pe,	2734.2	9.3 L,
	2737.7	9.2 Bs,	2741.7	9.3 Bs,	2743.8	9.4 Bs,	2745.2	9.3 Pe,
	2745.5	9.2 Ya,	2748.3	8.9 L,	2751.5	8.9 Pt,	2752.7	9.8 Bs.
022150 RR PERSEI—								
	2746.5	10.1 Y.						
022813 U CETI—								
	2697.1	8.3 Ch,	2746.5	10.3 Y.				
023133 R TRIANGULI—								
	2719.7	9.2 Ml,	2745.5	8.6 Ya,	2745.5	9.5 Cg,	2751.6	8.2 Pt,
	2759.5 <9.8 Cg,		2760.6	7.8 B,	2765.6	9.5 Hl.		
024356 W PERSEI—								
	2745.6	9.4 Ya,	2746.7	9.6 Mu,	2751.6	10.1 Pt.		
030514 U ARIETIS—								
	2699.3	13.8 Gi,	2717.3	13.0 Gi,	2730.4	12.5 Gi,	2741.4	12.3 Gi,
	2746.6	11.6 Y.						
031401 X CETI—								
	2734.3	9.0 L,	2748.3	8.8 L,	2751.6	9.1 Pt.		
032043 Y PERSEI—								
	2745.6	8.8 Ya,	2751.6	8.9 Pt.				
032335 R PERSEI—								
	2694.5	8.8 Gi,	2709.4	9.2 Gi,	2725.4	9.7 Gi,	2738.4	10.7 Gi,
	2751.6	11.0 Pt.						

VARIABLE STAR OBSERVATIONS, February 20 to March 20, 1921—Continued.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.
042209 R TAURI—								
	2750.6	12.3 B,	2751.6	12.4 Pt.				
042215 W TAURI—								
	2725.3	9.9 Pe,	2751.6	10.1 Pt,	2753.6	9.9 Du,	2760.6	9.6 B,
	2760.6	10.4 Pw,	2765.5	9.8 Du.				
042309 S TAURI—								
	2750.6<13.4 B.							
043208 RX TAURI—								
	2758.6	13.1 Pt.						
043274 X CAMELOPARDALIS—								
	2746.6	11.5 Y,	2753.6	11.6 B,	2758.7	11.3 Pt.		
044617 V TAURI—								
	2753.6	9.0 B,	2758.6	10.6 Pt.				
045307 R ORIONIS—								
	2699.4	12.1 Gi,	2717.4	12.3 Gi,	2730.4	12.6 Gi,	2746.4	12.2 Gi,
	2746.6	12.0 Y,	2750.6	12.7 B.				
045514 R LEPORIS—								
	2697.1	9.3 Ch,	2718.4	8.4 Rk,	2724.3	7.6 Rk,	2725.4	8.8 L,
	2733.3	7.9 Rk,	2735.3	7.6 L,	2740.4	7.5 Rk,	2744.4	7.5 Rk,
	2745.5	8.8 Ya,	2748.3	7.9 L,	2751.6	8.4 Pt.		
050003 V ORIONIS—								
	2746.6	12.1 Y,	2750.6	10.8 Jd,	2750.6	11.9 B.		
050022 T LEPORIS—								
	2751.6	9.4 Pt,	2753.6	9.2 Ya.				
050953 R AURIGAE—								
	2747.6	12.8 Lv,	2753.6	12.6 Lv,	2758.6	12.2 Pt.		
052034 S AURIGAE—								
	2723.4	9.1 L,	2747.4	8.5 L,	2759.6	9.0 Hk,	2760.6	8.8 B,
	2760.7	9.1 Ya,	2762.6	9.2 Hk,	2765.5	9.1 Hk.		
052036 W AURIGAE—								
	2699.4	12.1 Gi,	2717.5	12.4 Gi,	2723.4	12.8 L,	2730.5	12.6 Gi,
	2747.4	13.2 Gi,	2747.4<12.5 L.					
052404 S ORIONIS—								
	2750.6	10.8 B.						
053005a T ORIONIS—								
	2721.4	10.0 L,	2723.4	9.9 L,	2725.4	10.3 L,	2734.3	9.8 L,
	2736.3	10.9 Pe,	2737.4	10.3 L,	2741.4	9.8 L,	2743.4	10.0 L,
	2747.4	9.9 L,	2748.3	10.2 L,	2751.6	10.4 Pt,	2753.6	10.9 Ya,
053068 S CAMELOPARDALIS—								
	2751.6	8.5 Pt.						
053326 RR TAURI—								
	2724.3	11.5 Ja,	2732.3	11.4 Ja,	2735.3	11.3 Ja,	2744.3	11.7 Ja,
	2749.4	12.0 Ja.						
053531 U AURIGAE—								
	2732.6<11.2 Pw,		2746.6	10.8 Y,	2751.6	10.2 Pt,	2759.6	9.7 Ya.
054319 SU TAURI—								
	2694.1	9.5 Ch,	2701.0	10.1 Jk,	2704.9	10.1 Jk,	2715.1	9.6 Ch,
	2721.0	9.7 Jk,	2721.9	9.7 Jk,	2723.4	9.6 L,	2733.3	9.9 Pe,
	2734.3	9.4 L,	2737.6	9.3 B,	2739.5	9.5 B,	2746.6	9.5 Y,
	2747.4	9.4 Rk,	2747.5	9.5 L,	2748.4	9.4 L,	2751.6	9.5 Pt,
	2756.6	9.7 Pt,	2758.6	9.4 Pt,	2759.6	9.6 Pt,	2763.6	9.6 Pt,
054920 U ORIONIS—								
	2694.1	10.5 Ch,	2734.6	11.7 Lv,	2735.6	11.8 Lv,	2736.6	11.8 Lv,
	2745.5	<9.7 Cg,	2750.6	11.3 B,	2751.6	12.3 Pt,	2751.6	11.9 Lv,
	2759.5	<9.9 Cg,	2759.6	11.8 Lv.				
054920 UW ORIONIS—								
	2734.6	10.2 Lv,	2735.6	10.3 Lv,	2736.6	10.2 Lv,	2751.6	10.4 Lv,
	2759.6	11.1 Lv.						
054974 V CAMELOPARDALIS—								
	2707.4<14.0 Gi,		2718.3<14.0 Gi,		2734.5<14.0 Gi,			
	2746.5<13.5 B,		2746.6<13.0 Y,		2753.6<13.5 B.			

VARIABLE STAR OBSERVATIONS, February 20 to March 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
055353 Z AURIGAE—												
	2751.7	10.7	Pt,	2759.6	10.5	Ya.						
060450 X AURIGAE—												
	2746.5	12.0	Ro,	2748.5	12.0	Ro,	2752.5	11.7	Ro,	2758.6	11.0	Pt,
	2764.5	10.8	Ro.									
060547 SS AURIGAE—												
	2691.1	<11.8	Ch,	2694.4	<13.8	Gi,	2699.4	<13.8	Gi,	2704.4	<13.8	Gi,
	2705.0	<10.8	Jk,	2705.4	12.7	Rk,	2707.4	<13.8	Gi,	2709.4	<13.8	Gi,
	2710.3	<13.3	Gi,	2711.3	<13.3	Gi,	2715.3	<13.8	Gi,	2717.5	<13.8	Gi,
	2718.4	<13.8	Gi,	2719.2	<13.8	Gi,	2720.3	<13.8	Gi,	2721.0	<11.0	Jk,
	2721.4	<13.7	L,	2722.0	<10.5	Jk,	2723.2	<13.3	Ja,	2723.3	<14.0	Gi,
	2723.3	<14.0	L,	2724.3	<13.3	Ja,	2724.6	<12.4	L,	2725.3	<13.8	Gi,
	2725.4	<13.3	Ja,	2726.4	<14.0	L,	2730.4	<14.0	Gi,	2732.3	13.6	Ja,
	2734.3	12.0	L,	2734.4	12.7	Ja,	2734.4	12.4	Gi,	2734.6	12.3	L,
	2735.3	12.0	Ja,	2735.6	11.8	L,	2736.2	10.9	L,	2736.4	11.6	Gi,
	2736.5	11.4	Ja,	2736.6	10.9	L,	2737.4	10.9	L,	2737.4	10.8	Ja,
	2737.5	11.1	B,	2738.3	11.2	Gi,	2738.4	10.8	Ja,	2739.4	11.2	Ja,
	2739.4	11.4	Gi,	2739.5	11.7	B,	2740.3	11.7	Gi,	2740.4	11.6	Ja,
	2741.4	12.3	L,	2741.4	12.4	Gi,	2742.4	13.0	Gi,	2743.4	12.7	Ja,
	2743.4	<13.3	Gi,	2743.4	<12.4	L,	2744.3	<13.3	Ja,	2744.4	<13.5	Gi,
	2746.3	14.0	L,	2746.4	<13.8	Gi,	2747.4	<13.5	L,	2747.4	<13.9	Gi,
	2748.4	<13.9	Gi,	2748.4	<14.0	L,	2749.5	<13.3	Ja,	2751.6	<12.6	Pt,
	2756.6	<12.6	Pt,	2758.6	<12.6	Pt,	2759.7	<12.6	Pt,	2763.6	<12.4	Pt.
061702 V MONOCEROTIS—												
	2758.6	12.8	Pt.									
063159 U LYNCIS—												
	2746.6	<13.0	Y.									
063308 R MONOCEROTIS—												
	2735.6	10.7	Pw,	2750.6	10.9	Pw,	2750.6	11.5	Hl.			
063558 S LYNCIS—												
	2758.6	13.0	Pt.									
064030 X GEMINORUM—												
	2699.5	10.2	Gi,	2717.4	11.4	Gi,	2730.4	11.9	Gi,	2747.4	12.2	Gi.
064707 W MONOCEROTIS—												
	2735.6	10.4	Pw,	2745.6	9.5	B,	2751.7	10.4	Pt,	2759.6	10.5	Ya.
065111 Y MONOCEROTIS—												
	2746.6	13.3	Y,	2749.6	<12.3	B,	2759.5	<12.3	Ya.			
065208 X MONOCEROTIS—												
	2723.4	7.6	L,	2737.4	8.0	L,	2748.4	8.1	L,	2759.5	9.0	Ya,
	2759.7	9.1	Hk,	2765.5	9.1	Hk.						
065355 R LYNCIS—												
	2707.5	12.9	Gi,	2718.5	12.8	Gi,	2734.5	11.8	Gi,	2746.6	11.0	Y,
	2747.4	11.2	Gi,	2758.7	10.8	Pt.						
070109 V CANIS MINORIS—												
	2750.6	13.5	Hl,	2750.6	13.2	Pw.						
070122 R GEMINORUM—												
	2691.1	8.8	Ch,	2705.0	8.9	Jk,	2729.7	9.5	Jd,	2735.7	9.4	Jd,
	2751.6	11.3	Lv,	2751.7	10.4	Pt,	2759.6	11.2	Lv.			
070122b Z GEMINORUM—												
	2705.0	8.2	Jk,	2751.6	12.6	Lv,	2751.7	12.4	Pt,	2759.6	12.6	Lv.
070122c TW GEMINORUM—												
	2705.0	<10.2	Jk,	2751.6	8.4	Lv,	2759.6	8.2	Lv.			
070310 R GEMINORUM—												
	2725.5	8.2	L,	2748.4	8.2	L,	2762.6	8.5	Ya.			
071044 L_2 PUPPIS—												
	2694.2	4.3	Ch.									
071713 V GEMINORUM—												
	2746.6	13.5	B.									
072708 S CANIS MINORIS—												
	2691.1	<11.5	Ch,	2704.3	<10.0	Rk,	2718.4	<10.0	Rk,	2721.4	<10.0	Rk,
	2733.4	<10.0	Rk,	2742.4	<10.0	Rk,	2746.5	12.0	Ro,	2746.6	<11.0	Mu.

VARIABLE STAR OBSERVATIONS, February 20 to March 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
072708 S CANIS MINORIS—												
	2746.6	11.7	B,	2748.4	11.7	L,	2748.5	12.2	Ro,	2749.5	12.2	Ro,
	2750.6	12.1	Pw,	2752.5	12.3	Ro,	2753.6	<10.0	Po,	2761.5	10.8	Ro,
	2762.5	10.5	Ro,	2764.5	10.5	Ro.						
072811 T CANIS MINORIS—												
	2751.7	10.8	Pt,	2761.5	9.7	B.						
073508 U GEMINORUM—												
	2723.4	12.5	L,	2737.4	12.7	L,	2746.6	13.0	Y,	2748.4	13.0	L,
	2751.5	12.8	B,	2760.6	12.5	Hl.						
073723 S GEMINORUM—												
	2746.6	10.8	B,	2753.7	10.0	Po,	2758.7	9.8	Pt.			
074323 T GEMINORUM—												
	2763.5	9.5	B,	2765.7	9.7	Po.						
074922 U GEMINORUM—												
	2691.1	<12.3	Ch,	2694.4	14.0	Gi,	2695.0	<9.3	Jk,	2699.5	14.0	Gi,
	2704.4	14.0	Gi,	2704.9	<10.9	Jk,	2705.4	<10.9	Rk,	2707.5	13.9	Gi,
	2709.4	13.7	Gi,	2710.3	<13.3	Gi,	2711.3	<13.3	Gi,	2715.3	<13.3	Gi,
	2717.5	<13.7	Gi,	2718.4	14.0	Gi,	2720.3	14.0	Gi,	2721.0	<11.4	Jk,
	2721.4	14.0	L,	2722.0	<10.2	Jk,	2722.7	<11.7	Jd,	2723.3	13.9	Gi,
	2723.4	<13.7	L,	2724.3	<13.7	Ja,	2724.6	<13.3	L,	2725.3	14.0	Gi,
	2725.4	<13.7	Ja,	2725.4	14.0	L,	2730.3	14.0	Gi,	2732.4	<12.3	Ja,
	2734.3	<13.7	L,	2734.4	13.9	Gi,	2734.4	<13.3	Ja,	2735.3	<12.6	Ja,
	2736.4	13.9	Gi,	2736.5	<13.3	Ja,	2736.6	<12.4	L,	2737.4	<13.3	L,
	2737.6	<13.3	B,	2738.4	<13.3	Gi,	2739.4	<13.3	Gi,	2739.5	<12.0	Y,
	2741.4	<12.9	Gi,	2741.4	<11.0	L,	2742.4	<13.3	Gi,	2743.4	<13.3	Gi,
	2743.4	<12.4	L,	2744.3	<12.3	Ja,	2744.4	<13.3	Gi,	2745.3	<12.4	Rk,
	2745.5	<13.8	B,	2746.3	<11.0	L,	2746.4	<13.7	Gi,	2746.6	<13.3	Y,
	2747.4	<13.3	Rk,	2747.4	14.0	Gi,	2747.4	<13.7	L,	2748.4	13.9	Gi,
	2748.4	14.1	L,	2749.4	14.0	L,	2749.5	<13.7	Ja,	2751.6	<13.3	Pt,
	2756.6	<12.4	Pt,	2758.6	<13.7	Pt,	2759.6	<13.7	Pt,	2762.5	11.4	Ya,
	2763.6	<12.4	Pt,	2767.6	9.7	Pi,	2769.7	9.2	M.			
081112 R CANCRI—												
	2691.2	10.1	Ch,	2735.6	8.5	Pw,	2743.4	9.0	L,	2750.6	8.8	Pw,
	2750.6	8.5	Hl,	2750.6	8.7	Cg,	2750.6	8.7	Du,	2751.7	8.6	Pt,
	2759.6	8.2	My,	2760.5	8.4	Cg,	2762.6	8.3	Ya,	2765.5	8.0	Du,
	2765.7	8.3	Po,	2770.6	8.0	My.						
081617 V CANCRI—												
	2707.5	13.0	Gi,	2718.4	11.9	Gi,	2725.3	11.6	Ja,	2730.5	10.7	Gi,
	2732.4	11.1	Ja,	2738.4	10.3	Ja,	2738.8	<11.2	Jd,	2741.4	9.8	Gi,
	2744.3	9.8	Ja,	2749.5	9.6	Ja,	2750.6	9.6	Du,	2756.6	9.2	Pt,
	2756.6	10.0	Hl,	2756.6	9.8	Pw,	2759.6	9.5	My,	2761.6	9.1	B,
	2762.6	9.0	Ya,	2765.6	8.9	Du,	2765.7	8.9	Po,	2770.6	8.7	My.
082405 RT HYDRAE—												
	2723.4	8.1	L,	2747.5	8.3	L.						
083019 U CANCRI—												
	2751.6	<13.5	B,	2760.6	12.2	Pw.						
083350 X URSAE MAJORIS—												
	2745.5	<9.0	Cg,	2745.6	10.8	B,	2750.6	10.1	Du,	2750.6	10.5	Pw,
	2756.8	9.8	Pt,	2762.5	<9.6	Cg,	2765.6	9.1	Du.			
084803 S HYDRAE—												
	2692.2	9.8	Ch,	2735.6	11.2	Pw,	2751.6	12.5	B,	2758.7	12.7	Pt,
	2760.6	13.2	Hl,	2760.6	13.2	Pw.						
085008 T HYDRAE—												
	2694.2	<11.0	Ch,	2733.5	12.5	L,	2747.5	<13.7	L,	2751.6	13.0	B,
	2758.7	12.8	Pt,	2760.6	<13.0	Pw,	2760.6	<11.0	Hl.			
085120 T CANCRI—												
	2723.4	7.9	L,	2735.6	9.0	Pw,	2743.4	7.9	L,	2756.6	8.5	Hl,
	2756.6	8.3	Pw,	2758.7	8.4	Pt	2765.6	9.0	Ya.			
090024 S PYXIDIS—												
	2759.6	9.9	Pt.									
090425 W CANCRI—												
	2736.7	11.6	L,	2748.4	11.5	L,	2760.6	<11.0	Hl.			

VARIABLE STAR OBSERVATIONS, February 20 to March 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
093014 X HYDRAE—												
	2746.7	9.1	Mu,	2760.6	9.9	Pw,	2760.6	10.0	Hl,	2763.6	8.9	B,
	2765.6	9.0	Ya.									
093178 Y DRACONIS—												
	2746.6	13.3	Y,	2750.6	<12.0	Hl,	2750.6	<10.0	Pw.			
093934 R LEONIS MINORIS—												
	2691.2	10.3	Ch,	2704.2	9.5	Ch,	2725.5	8.4	L,	2736.7	7.6	L,
	2748.3	7.5	L,	2748.5	7.4	Ro,	2749.5	7.4	Ro,	2750.5	7.5	Ro,
	2752.5	7.5	Ro,	2753.5	7.5	B,	2755.5	7.5	Ro,	2756.6	7.4	Pt,
	2761.5	7.7	Ro,	2763.8	8.3	M,	2765.6	7.5	Ya,	2765.6	8.3	Hl,
	2765.7	7.6	Po.									
094211 R LEONIS—												
	2691.5	6.2	El,	2694.2	5.7	Ch,	2698.5	6.2	El,	2703.4	6.1	El,
	2710.4	6.4	El,	2721.5	6.3	El,	2725.3	6.5	Pe,	2733.3	7.5	Pe,
	2733.5	5.9	Rk,	2736.3	7.1	Pe,	2737.7	5.9	Bs,	2744.4	6.7	Rk,
	2744.8	6.6	Bs,	2745.6	6.5	B,	2746.5	6.3	Ro,	2746.6	6.8	Mu,
	2748.5	6.6	Su,	2748.5	6.4	Ro,	2749.3	7.0	Pe,	2749.5	6.4	Ro,
	2750.5	6.4	Ro,	2750.6	6.7	Jd,	2751.7	6.6	Pt,	2752.5	6.4	Ro,
	2752.5	7.5	Cg,	2755.5	6.5	Ro,	2759.6	7.8	My,	2759.8	7.2	Hk,
	2760.5	8.0	Cg,	2760.7	7.2	Hk,	2761.5	6.7	Ro,	2762.5	6.8	Ro,
	2765.5	7.0	Ro,	2765.5	7.5	Hk,	2765.6	8.2	Ya,	2765.8	7.4	M,
	2768.5	7.2	Ro,	2770.6	7.9	My.						
094622 Y HYDRAE—												
	2758.7	7.2	Pt,	2765.6	7.5	Ya.						
095421 V LEONIS—												
	2724.5	10.3	Ja,	2732.4	9.8	Ja,	2738.4	9.2	Ja,	2744.3	8.7	Ja,
	2749.4	8.6	Ja,	2756.6	8.6	Pt,	2760.6	8.6	B,	2763.8	8.9	M,
	2765.6	8.8	Hl.									
103212 U HYDRAE—												
	2747.5	5.0	L.									
103769 R URSAE MAJORIS—												
	2691.5	8.4	El,	2698.4	8.7	El,	2704.2	8.8	Ch,	2721.5	<9.0	El,
	2746.7	10.5	Bs,	2750.7	11.0	Du,	2751.7	11.0	Pt,	2756.8	11.5	M,
	2763.6	10.6	My,	2765.6	11.5	Du,	2770.6	10.8	My.			
104620 V HYDRAE—												
	2747.5	7.1	L,	2756.6	6.8	Pt.						
104814 W LEONIS—												
	2746.6	10.5	Y,	2756.6	11.1	Pt,	2763.8	11.0	M.	2765.6	10.5	Y.
110506 S LEONIS—												
	2753.6	9.9	Du,	2756.6	10.1	Pt,	2765.6	10.6	Du.			
115919 R COMAE BERENICIS—												
	2734.5	<12.5	Ja,	2749.5	<12.5	Ja.						
120012 SU VIRGINIS—												
	2724.5	12.1	Ja,	2734.5	12.5	Ja,	2744.9	<12.8	Ja.			
121418 R CORVI—												
	2724.7	<11.7	L,	2758.7	11.1	Pt,	2759.8	11.5	M.			
122001 SS VIRGINIS—												
	2734.6	7.2	L,	2746.6	7.2	L,	2768.8	8.4	M.			
122532 T CANUM VENATICORUM—												
	2746.8	8.8	Bs,	2756.6	9.6	Pt,	2759.8	10.4	M.			
122803 Y VIRGINIS—												
	2723.5	12.0	L,	2736.7	12.9	L.						
123160 T URSAE MAJORIS—												
	2704.2	<11.0	Ch,	2725.3	12.0	Pe,	2729.7	<10.8	Jd,	2733.3	10.6	Pe,
	2733.8	<10.4	Jd,	2744.7	10.3	Bs,	2745.3	9.0	Pe,	2745.8	10.0	Bs,
	2746.7	8.7	Mu,	2751.7	8.9	Pt,	2756.8	8.1	M,	2762.5	7.7	Ro,
	2764.5	7.5	Ro,	2767.7	7.3	Po,	2768.5	7.3	Jd,	2770.6	7.4	My.
123307 R VIRGINIS—												
	2720.9	11.5	Ml,	2723.5	10.9	L,	2736.4	9.2	Pe,	2736.7	9.5	L,
	2748.4	8.1	L,	2756.6	7.7	Pt	2768.8	7.2	M.			

VARIABLE STAR OBSERVATIONS, February 20 to March 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
123459 RS URSAE MAJORIS—												
	2704.2	9.4	Ch,	2725.3	10.9	Pe,	2733.3	11.9	Pe,	2746.7	<10.9	Mu,
	2751.7	12.0	Pt;	2756.8	11.8	M,	2767.7	<10.8	Po.			
123961 S URSAE MAJORIS—												
	2698.5	8.6	El,	2703.4	8.8	El,	2704.2	8.4	Ch,	2721.5	9.2	El,
	2725.3	9.1	Pe,	2725.5	9.2	L,	2729.8	9.3	Jd,	2733.3	9.0	Pe,
	2733.8	9.5	Jd,	2736.7	10.3	L,	2741.7	9.4	Bs,	2742.8	9.5	Bs,
	2744.7	9.5	Bs,	2745.3	9.9	Pe,	2745.8	9.5	Bs,	2746.7	10.0	Mu,
	2748.4	10.0	L,	2750.6	9.9	Jd,	2751.7	10.3	Pt,	2764.5	11.5	Ro,
	2767.7	11.2	Po,	2770.6	10.6	My.						
124204 RU VIRGINIS—												
	2736.5	<12.8	Ja,	2749.5	<12.5	Ja.						
125606 U VIRGINIS—												
	2736.5	<12.2	Ja,	2749.5	<12.2	Ja.						
130212 RV VIRGINIS—												
	2756.8	11.7	Pt.									
132422 R HYDRAE—												
	2694.6	5.8	Gi,	2698.4	6.2	Ch,	2709.7	6.5	Gi,	2725.7	7.1	Gi,
	2734.7	6.4	L,	2740.7	7.7	Gi,	2756.8	8.2	Pt.			
132706 S VIRGINIS—												
	2758.7	7.1	Pt,	2768.8	7.2	M.						
134440 R CANUM VENATICORUM—												
	2721.0	10.4	Ml,	2746.7	10.6	Bs,	2756.6	9.5	Pt,	2763.8	9.2	M,
	2765.6	9.1	Y,	2767.7	9.4	Po.						
135908 RR VIRGINIS—												
	2758.8	13.1	Pt.									
140113 Z BOÖTIS—												
	2760.7	<13.0	Hl,	2765.6	<13.4	Y.						
141567 U URSAE MINORIS—												
	2751.7	10.4	Pt,	2767.7	9.8	Po.						
141954 S BOÖTIS—												
	2694.6	8.7	Gi,	2709.7	8.5	Gi,	2715.5	8.3	Ch,	2725.4	8.5	Gi,
	2725.5	8.3	L,	2740.7	8.6	Gi,	2741.4	8.7	L,	2756.6	9.1	Pt.
142205 RS VIRGINIS—												
	2736.5	12.2	Ja,	2749.5	10.9	Ja.						
142539 V BOÖTIS—												
	2725.5	9.2	L,	2741.4	9.5	L,	2748.6	9.2	Ro,	2749.4	9.7	L,
	2752.6	9.7	Ro,	2756.6	9.7	Pt,	2759.6	9.9	Ro,	2759.6	9.9	O,
	2759.6	9.9	Ht,	2760.8	10.1	M,	2761.6	10.0	Ro,	2764.6	10.2	Ro.
142584 R CAMELOPARDALIS—												
	2707.4	9.5	Gi,	2718.4	10.3	Gi,	2734.5	11.1	Gi,	2747.5	11.7	Gi.
143227 R BOÖTIS—												
	2758.8	10.3	Pt,	2763.8	9.2	M,	2765.6	7.9	Su.			
144918 U BOÖTIS—												
	2694.6	10.8	Gi,	2709.7	10.8	Gi,	2725.7	10.3	Gi,	2740.7	10.8	Gi,
	2767.6	11.5	Pi.									
150605 Y LIBRAE—												
	2735.7	<13.2	L.									
151520 S LIBRAE—												
	2707.5	<11.0	Ch,	2724.7	10.4	L,	2746.7	9.5	L,	2763.8	8.8	Pt.
151714 S SERPENTIS—												
	2734.7	<13.5	L,	2736.5	12.8	Ja,	2736.7	14.0	L,	2767.6	<11.5	Pi.
151731 S CORONAE BOREALIS—												
	2715.5	7.6	Ch,	2739.7	7.7	Cd.	2745.6	7.8	Cd,	2751.8	7.6	Pt,
	2753.6	8.0	Cd,	2759.8	8.2	M,	2767.6	8.8	Pi,	2767.8	8.5	Po.
151822 RS LIBRAE—												
	2724.7	8.7	L,	2735.7	8.1	L.						
152714 RU LIBRAE—												
	2724.7	<13.0	L,	2735.7	<13.1	L.						
153378 S URSAE MINORIS—												
	2742.7	11.0	Bs,	2745.8	11.4	Bs,	2746.6	11.0	Ro,	2746.7	11.4	Mu,
	2748.6	11.0	Ro,	2751.7	11.4	Pt,	2764.6	10.4	Ro.			

VARIABLE STAR OBSERVATIONS, February 20 to March 20, 1921—Continued.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.
154428 R CORONAE BOREALIS—								
	2694.7	6.3 Gi,	2709.7	6.3 Gi,	2715.5	6.0 Ch,	2717.7	6.1 Gi,
	2723.5	5.9 L,	2724.7	6.0 L,	2725.6	6.2 Gi,	2734.6	6.2 L,
	2735.7	6.1 L,	2736.7	6.2 L,	2740.7	6.4 Gi,	2746.6	6.3 L,
	2747.5	6.7 L,	2747.5	6.8 Gi,	2748.4	6.7 L,	2749.4	6.8 L,
	2749.5	6.9 Ja,	2750.3	7.0 Pe,	2751.8	6.3 Pt,	2756.8	7.3 Pt,
	2758.7	7.5 Pt,	2759.7	7.7 Pt,	2759.7	7.9 Hk,	2759.8	8.0 M,
	2760.8	8.1 M,	2762.7	8.2 Hk,	2762.8	8.4 M,	2763.8	8.4 Pt,
	2763.8	8.5 M,	2764.9	8.7 Pt,	2765.6	9.0 Y,	2765.7	9.4 E,
	2765.7	8.7 Hk,	2765.8	8.8 M,	2767.6	9.3 Pi,	2767.7	9.5 Hk,
	2767.8	9.2 M,	2767.9	9.1 Pt,	2768.8	9.4 M,	2769.7	9.5 M,
	2771.7	8.9 Hk.						
154536 X CORONAE BOREALIS—								
	2759.8	11.1 M.						
154615 R SERPENTIS—								
	2736.6	7.6 Ja,	2749.5	7.0 Ja,	2751.8	6.9 Pt,	2759.8	7.1 M.
154639 V CORONAE BOREALIS—								
	2751.8	8.6 Pt,	2759.8	9.7 M.				
155018 RR LIBRAE—								
	2707.5	9.0 Ch,	2735.7	9.8 L.				
155823 RZ SCORPII—								
	2758.8	11.8 Pt.						
160021 Z SCORPII—								
	2721.7	9.2 L,	2746.7	9.9 L.				
160210 U SERPENTIS—								
	2758.8	11.6 Pt,	2759.8	11.0 M.				
160625 RU HERCULIS—								
	2759.8<12.3 M.							
161122a R SCORPII—								
	2736.6<12.4 Ja,		2758.8	11.8 Pt.				
161122b S SCORPII—								
	2736.6<12.4 Ja,		2758.8	13.0 Pt.				
161138 W CORONAE BOREALIS—								
	2751.8	8.4 Pt,	2759.8	9.0 M.				
161607 W OPHIUCHI—								
	2734.7	12.7 L,	2767.9	11.7 Pt.				
162119 U HERCULIS—								
	2709.7	7.9 Gi,	2715.5	8.2 Ch,	2725.7	8.6 Gi,	2742.7	8.8 Gi,
	2751.8	9.0 Pt,	2759.8	9.2 M.				
162807 SS HERCULIS—								
	2746.7	11.8 L,	2758.8	10.6 Pt.				
163137 W HERCULIS—								
	2715.5<11.0 Ch,		2759.8<12.0 M.					
163172 R URSAE MINORIS—								
	2763.8	10.0 M.						
163266 R DRACONIS—								
	2746.7	10.5 Bs,	2763.8	12.0 M,	2765.6	11.6 Y.		
164055 S DRACONIS—								
	2763.8	8.8 M.						
164715 S HERCULIS—								
	2711.7	8.7 Gi,	2736.6	8.2 Gi,	2748.7	7.8 Gi,	2758.8	7.0 Pt,
	2763.8	7.8 M.						
165202 SS OPHIUCHI—								
	2767.9	11.1 Pt.						
165631 RV HERCULIS—								
	2736.6	13.0 Ja,	2749.5	12.5 Ja,	2751,8	12.3 Pt,	2757.9	12.1 E,
	2759.8	11.7 M.						
170215 R OPHIUCHI—								
	2757.9	8.0 E,	2758.8	8.0 Pt.				
170627 RT HERCULIS—								
	2758.8	8.8 Pt.						
171401 Z OPHIUCHI—								
	2711.7	8.5 Gi,	2736.6	8.0 Gi,	2748.7	8.0 Gi,	2756.8	7.9 Pt.

VARIABLE STAR OBSERVATIONS, February 20 to March 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
171723 RS HERCULIS—												
	2736.7	8.5	Ja,	2758.8	8.4	Pt,	2759.8	8.8	M.			
172809 RU OPHIUCHI—												
	2758.8	12.6	Pt,	2759.8	<11.6	M.						
175458a T DRACONIS—												
	2709.7	<12.3	Gi,	2738.7	12.6	Gi,	2763.8	11.0	M.			
175458b UY DRACONIS—												
	2763.8	11.4	M.									
175519 RY HERCULIS—												
	2757.9	<13.4	E,	2758.8	13.6	Pt.						
180531 T HERCULIS—												
	2715.5	8.2	Ch,	2721.7	8.3	L,	2746.7	10.8	L,	2751.8	11.6	Pt,
	2763.8	11.8	M.									
180565 W DRACONIS—												
	2751.8	11.8	Pt,	2763.8	<11.3	M.						
180666 X DRACONIS—												
	2763.8	<11.3	M.									
180911 NOVA OPHIUCHI #4—												
	2711.7	11.3	Gi,	2736.7	11.1	L,	2739.6	11.3	Gi,	2756.9	11.5	Pt,
	2758.8	11.4	Pt,	2764.9	11.4	Pt.						
181031 TV HERCULIS—												
	2724.7	9.5	L,	2746.7	9.8	L.						
181103 RY OPHIUCHI—												
	2711.7	12.9	Gi,	2736.7	12.4	Gi,	2748.7	11.7	Gi.			
181136 W LYRAE—												
	2735.7	10.4	L,	2738.9	10.3	E,	2751.8	10.8	Pt,	2759.8	12.0	M.
182224 SV HERCULIS—												
	2734.7	9.9	L,	2758.9	11.0	Pt.						
182306 T SERPENTIS—												
	2758.9	10.4	Pt.									
183225 RZ HERCULIS—												
	2758.9	10.0	Pt.									
183308 X OPHIUCHI—												
	2734.7	8.1	L,	2738.9	8.4	E.						
184205 R SCUTI—												
	2724.7	5.2	L,	2730.9	5.3	Cd,	2741.9	5.6	Cd,	2746.7	5.4	L,
	2756.9	5.3	Pt,	2758.9	5.6	Pt,	2759.9	5.6	Pt,	2763.9	5.5	Pt,
	2764.9	5.6	Pt,	2767.9	5.7	Pt.						
184243 RW LYRAE—												
	2738.9	<13.4	E,	2757.9	<13.4	E.						
184300 NOVA AQUILAE #3—												
	2717.7	9.4	Gi,	2739.7	9.4	Gi,	2746.7	9.3	L,	2751.8	9.3	Pt,
	2756.9	9.0	Pt,	2758.9	9.1	Pt,	2759.9	9.2	Pt,	2763.9	9.2	Pt,
	2767.9	9.2	Pt.									
184929 NOVA LYRAE #1—												
	2717.7	13.0	Gi,	2739.7	12.9	Gi.						
185032 RX LYRAE—												
	2758.9	13.0	Pt.									
190108 R AQUILAE—												
	2758.9	10.7	Pt.									
190925 S LYRAE—												
	2735.7	11.5	L,	2767.9	11.6	Pt.						
190926 X LYRAE—												
	2768.8	8.0	M.									
191019 R SAGITTARII—												
	2759.9	9.6	Pt.									
191033 RY SAGITTARII—												
	2763.9	6.1	Pt,	2764.9	6.3	Pt.						
191637 U LYRAE—												
	2758.9	10.8	Pt.									
192928 TY CYGNI—												
	2738.9	10.9	E,	2757.9	11.4	E,	2758.9	12.0	M,	2758.9	12.3	Pt.

VARIABLE STAR OBSERVATIONS, February 20 to March 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
193449 R CYGNI—												
	2715.5	7.0	Ch,	2756.9	7.4	Pt,	2758.9	6.8	M.			
193509 RV AQUILAE—												
	2758.9	9.9	Pt.									
193732 TT CYGNI—												
	2738.9	7.9	E,	2757.9	8.2	E.						
194048 RT CYGNI—												
	2700.3	7.3	Gi,	2715.2	7.3	Gi,	2715.5	6.8	Ch,	2736.7	7.7	Gi,
	2748.7	8.3	Gi,	2756.9	9.0	Pt,	2758.9	9.0	M.			
194348 TU CYGNI—												
	2758.9	11.9	M,	2759.9	12.0	Pt.						
194604 X AQUILAE—												
	2767.9	8.9	Pt.									
194632 χ CYGNI—												
	2738.9	<12.2	E,	2757.9	13.2	E.						
195553 NOVA CYGNI #3—												
	2694.3	9.6	Gi,	2707.2	9.7	Gi,	2718.3	9.7	Gi,	2720.9	8.9	Kd,
	2721.9	9.0	Kd,	2723.3	9.5	Mt,	2727.9	8.8	Kd,	2728.9	9.0	Kd,
	2738.9	9.4	E,	2739.7	9.8	Gi,	2742.3	9.8	Mt,	2744.3	8.5	L,
	2751.8	9.3	Pt,	2756.8	9.2	Pt,	2757.9	9.4	E,	2758.9	9.3	Pt,
	2759.8	9.3	Pt,	2763.8	9.3	Pt,	2764.9	9.3	Pt,	2767.9	9.3	Pt,
195849 Z CYGNI—												
	2700.3	8.8	Gi,	2715.2	8.8	Gi,	2736.7	10.1	Gi,	2756.9	11.4	Pt,
	2758.9	11.4	M.									
200212 SY AQUILAE—												
	2735.7	10.8	L,	2763.9	10.8	Pt.						
200715 S AQUILAE—												
	2694.2	9.3	Gi,	2725.7	9.4	Gi,	2738.7	9.5	Gi,	2756.9	9.4	Pt.
200906 Z AQUILAE—												
	2763.9	10.3	Pt.									
200938 RS CYGNI—												
	2695.0	7.8	Ch,	2746.7	7.7	L,	2756.9	8.7	Pt,	2758.9	8.8	M.
201008 R DELPHINI—												
	2746.7	11.5	L.									
201437 P CYGNI—												
	2695.0	5.4	Ch.									
201647 U CYGNI—												
	2700.3	7.5	Gi,	2718.3	7.5	Gi,	2739.7	7.8	Gi,	2756.9	8.0	Pt,
	2758.9	7.8	M.									
202954 ST CYGNI—												
	2759.8	11.5	Pt.									
203226 V VULPECULAE—												
	2758.9	9.2	Pt.									
203847 V CYGNI—												
	2695.1	<11.0	Ch,	2707.3	11.0	Gi,	2740.7	10.4	Gi,	2763.8	<11.3	M.
204016 T DELPHINI—												
	2758.9	10.7	Pt.									
204318 V DELPHINI—												
	2694.2	<12.5	Gi.									
204405 T AQUARII—												
	2695.0	<11.0	Ch,	2763.9	7.6	Pt.						
204846 RZ CYGNI—												
	2707.3	11.7	Gi,	2742.7	13.1	Gi.						
205923 R VULPECULAE—												
	2694.3	12.0	Gi,	2710.3	11.9	Gi,	2739.7	8.9	Gi,	2759.9	7.9	Pt.
210129 TW CYGNI—												
	2759.9	9.8	Pt.									
210868 T CEPHEI—												
	2695.1	7.9	Ch,	2725.4	7.1	L,	2741.4	7.1	L,	2751.5	6.9	Pt.
211614 X PEGASI—												
	2700.2	11.3	Gi,	2718.2	9.6	Gi.						
213244 W CYGNI—												
	2736.3	5.7	L,	2744.3	5.8	L,	2746.3	5.7	L.			

VARIABLE STAR OBSERVATIONS, February 20 to March 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
213678 S CEPHEI—												
	2694.6	9.0	Gi,	2709.4	8.6	Gi,	2725.4	8.6	Gi,	2738.4	8.5	Gi.
213843 SS CYGNI—												
	2694.3	11.9	Gi,	2695.0<	10.4	Jk,	2697.2	12.0	Gi,	2701.0<	10.0	Jk,
	2704.9<	10.9	Jk,	2706.3	12.0	Gi,	2707.3	12.0	Gi,	2709.3	12.0	Gi,
	2710.3	12.0	Gi,	2711.3	12.0	Gi,	2715.0	10.8	Ch,	2715.3	9.6	Gi,
	2716.0	8.6	Ch,	2717.2	8.4	Gi,	2718.3	8.3	Gi,	2720.3	8.4	Gi,
	2720.9	8.2	Jk,	2723.2	8.3	Ja,	2723.4	8.2	L,	2724.3	8.3	Ja,
	2724.3	8.7	Mt,	2724.7	8.4	L,	2725.2	8.8	Gi,	2725.3	8.6	L,
	2729.7<	10.8	Jd,	2730.3	10.4	Gi,	2733.5	8.7	Jd,	2734.3	11.6	L,
	2734.3	11.8	Gi,	2736.2	11.7	L,	2736.3	11.8	Gi,	2738.3	11.8	Gi,
	2738.9	11.7	E,	2739.5	10.9	Y,	2740.3	11.8	Gi,	2743.3	11.8	Mt,
	2743.3	11.7	Gi,	2744.2	11.7	L,	2745.3	11.5	Mt,	2746.3	11.3	L,
	2746.5	11.5	Y,	2747.3	11.6	L,	2748.3	11.7	L,	2751.8	11.8	Pt,
	2756.9	11.8	Pt,	2757.9	11.8	E,	2758.9	12.0	M,	2758.9	11.7	Pt,
	2759.9	11.8	Pt,	2763.8<	11.3	M,	2763.9	11.8	Pt,	2764.9	11.9	Pt,
	2767.9	11.9	Pt.									
220412 T PEGASI—												
	2694.3<	13.5	Gi.									
220613 Y PEGASI—												
	2694.3<	13.4	Gi,	2718.3<	13.4	Gi.						
220714 RS PEGASI—												
	2700.3	13.4	Gi,	2718.3<	12.9	Gi.						
222439 S LACERTAE—												
	2707.3	8.2	Gi,	2719.3	8.1	Gi,	2725.3	8.4	L,	2736.3	8.9	Gi,
	2744.3	9.9	L,	2748.3	9.6	Gi.						
223841 R LACERTAE—												
	2707.4	12.9	Gi,	2725.3<	13.0	L,	2734.3	14.0	Gi,	2746.3<	12.4	L.
230110 R PEGASI—												
	2723.2	8.4	Ja.									
230759 V CASSIOPEIAE—												
	2694.4	10.5	Gi,	2709.3	11.2	Gi,	2725.3	12.1	Gi,	2739.8	11.5	Bs,
	2740.3	12.4	Gi,	2751.5	11.9	Pt.						
231425 W PEGASI—												
	2734.3	8.7	L,	2748.3	8.8	L.						
233335 ST ANDROMEDAE—												
	2692.2	10.0	Ch,	2751.5	9.1	Pt.						
233815 R AQUARII—												
	2695.1	6.9	Ch.									
235053 RR CASSIOPEIAE—												
	2694.4	13.8	Gi,	2717.3	12.7	Gi,	2734.3	11.7	Gi,	2747.3	11.4	Gi.
235209 V CETI—												
	2694.3	11.4	Gi,	2710.3	12.0	Gi.						
235350 R CASSIOPEIAE—												
	2694.5	10.8	Gi,	2715.3	11.5	Gi,	2734.3	12.1	Gi,	2739.8	11.4	Bs,
	2747.3	12.6	Gi.									
235525 Z PEGASI—												
	2723.2	11.8	Ja.									
235715 W CETI—												
	2699.2	10.2	Gi,	2711.3	9.5	Gi.						
235855 Y CASSIOPEIAE—												
	2694.5	10.4	Gi,	2709.3	10.7	Gi,	2725.3	10.8	Gi,	2738.3	11.4	Gi,
	2749.3	12.1	Gi.									

Eaton, "E," Ellsworth, "El," Ginori, "Gi," Hall, "Hl," Hatcher, "Ht," Hodgkinson, "Hk," Janczewski, "Ja," Miss Jenkins, "Jk," Jordan, "Jd," Kanda, "Kd," Lacchini, "L," Leavenworth, "Lv," McAteer, "M," Merrill, "Ml," Merton, "Mt," Mundt, "Mu," Murray, "My," Olcott, "O," Peltier, "Pt," de Perrot, "Pe," Pickering, "Pi," Potter, "Po," Reesinck, "Rk," Rhorer, "Ro," Suter, "Su," Watson, "Pw," Yalden, "Ya," and Miss Young, "Y."

Total Observations: 1,144. Stars Observed: 223. Observers: 34.

GENERAL NOTES.

Professor William H. Pickering has recently sailed from Mandeville, Jamaica, for Europe, to be gone a year. His address will be Care of Baring Bros., 8 Bishopsgate St. within, London, England.

Professor Henry Norris Russell, of Princeton University, a short time ago was awarded the Gold Medal of the Royal Astronomical Society "for his contributions to the study of Stellar Evolution." Professor Russell went to England to receive the medal in person. A recent letter from Professor Russell states that he will go to Pasadena early in May to work at the Mount Wilson Observatory as Research Associate.

Sr. Leon Herrero has been appointed the director of the Marine Institute and Observatory of San Fernando, Spain, as successor to Sr. D. Tomás de Azcárate whose death occurred on January 25, 1921.

Professor Albert Einstein, who recently came to the United States primarily in the interests of the Zionist movement, is devoting part of his time to giving scientific lectures in some of the eastern universities. On April 15 he lectured at Columbia University, and from April 18 to April 21, he gave a series of four lectures at the College of the City of New York. Arrangements have been made for a series of five lectures at Princeton University from May 9 to 13. The lectures will be given in German, and the subjects will be as follows:

Monday, May 9 and Tuesday, May 10, Generalities on the Theory of Relativity (without using mathematical symbols).

Wednesday, May 11, Special Theory of Relativity.

Thursday, May 12, General Theory of Relativity and Gravitation.

Friday, May 13, Cosmological Speculations.

Admission to the lectures will be by ticket, which may be secured by addressing a request to Professor H. D. Thompson, Princeton, N. J.

Relativity Prize.—In July, 1920, the editors of the *Scientific American* announced the offer, by one of its friends, Mr. Eugene Higgins, an American resident of Paris, of a prize of five thousand dollars ($5,000.00) for "the best essay on the Einstein postulates and their consequences, written so that a person with no special training may read it profitably." The contest was left in the hands of the *Scientific American*. No essay was to contain more than 3,000 words and all "must be in English, and written as simply, lucidly and non-technically as possible." The essays had to be in the office of the *Scientific* American by November 1, 1920. Professors Leigh Page, of Yale, and E. P. Adams, of Princeton, were the judges. In January, 1921, the prize was awarded to Mr. Lyndon Bolton, a senior examiner in the Patent Office, London. His "two most immediate rivals" were also Englishmen. Among the competitors were: Professor H. H. Turner, of Oxford University; Professor A. G. Webster, of Clark University; and Professor G. D. Birkhoff, of Harvard University, who "heads the list of mathematicians pure and simple who competed."

Nearly 300 essays were received. They came in greater quantity from Germany than from any other foreign country. England stood next on the list

and one or more essays were received from Austria, Canada, Chili, Cuba, Czechoslovakia, India, Jamaica, Jugoslavia, France, Switzerland, the Netherlands, Denmark, the Fiji Islands, Mexico, Italy, and South America.

Mr. Bolton's essay was published in the *Scientific American*, February 5, and in the *Westminster Gazette*, London, February 14.

(From the *American Mathematical Monthly*, April, 1921.)

Galileo's Father a Musician.—In the phrase "The Music of the Spheres" we have the art of music and the science of astronomy brought close together. The bond between the two is seen again in the latest catalog of Victor records in which we find, under a description of *Gagliarda* the following: "The gagliarda was the precursor of the minuet, which may be considered the precursor of the waltz. This gagliarda, which is a very famous one, was written by the father of Galileo Galilei, the great astronomer."

Van Vleck Observatory Telescope.—Word has recently been received by Professor Slocum that the rough disks for the 20-inch lens for the Van Vleck Observatory have arrived in Cambridge, Mass. The glass was ordered from Schott & Co., of Jena, Germany, in 1914, just before the war broke out, but it was not until the summer of 1920 that the disks were poured. The lens will be figured and ground by the Alvan Clark Co.

The Diameter of Arcturus.—On February 12, 1921, Mr. Francis G. Pease succeeded in measuring the diameter of Arcturus (α Boötis) with the 20-foot interferometer attached to the 100-inch Hooker telescope of the Mount Wilson Observatory. With the mirrors of the interferometer 19 feet apart the interference fringes were invisible, indicating angular diameter of 0″.024 for the star. Assuming the parallax of Arcturus to be 0″.12, which is very nearly correct, the diameter of the star becomes 0.2 of the earth's distance from the sun or approximately 19,000,000 miles.

Comet Medal Awarded.—The ninety-seventh award of the Donohoe Comet Medal of the Astronomical Society of the Pacific has recently been made to Mr. J. F. Skjellerup, of Rosebank, Cape Town, South Africa, for the discovery of an unexpected comet on December 9, 1920.—(*Publications of the Astronomical Society of the Pacific*, April, 1921.)

Meteor Seen in Daylight.—Newspaper clippings have been received containing accounts of brilliant meteors seen on the morning of April 20, about 8 A. M., both in Albany, Ga., and Macon, Ga. The account from Albany states that the luminous trail left behind in a cloudless sky was visible for two minutes. The report from Macon states that pieces of red hot metal, some weighing as much as six pounds, were seen to fall. No injuries were reported.

Austin Teaching Fellowship at Harvard.—Any of our readers who may be looking for an opportunity to continue in a systematic way the study of astronomy will be interested to know that an Austin Teaching Fellowship in Astronomy at Harvard is to be awarded for the coming year. Application for

appointment to this fellowship should be made promptly to Dr. H. T. Stetson, Department of Astronomy, Harvard University, Cambridge, Mass. The stipend is $750.00 a year.

Measures of Double Stars by Photography.—In *Publikationen des Astroph. Observ. Potsdam. Nr. 75* E. Hertzsprung outlines the photographic method that he has used for measuring double stars with great accuracy. This method cannot compete with the direct, visual one when it comes to separating close pairs; but for wider pairs it has advantages over the latter, and will be found especially valuable in the study of systems of the type of ζ Cancri or ξ Urs. Maj., where there are deviations from simple elliptic motion.

The plates were obtained with the 50 cm visual guiding telescope of the 80 cm photographic instrument at Potsdam. The two lenses have nearly the same focus of 12.58 meters. The visual lens is used in connection with yellow-sensitive plates, with or without a yellow color-fiter. The main difficulty in obtaining good photographic measures of double stars lies in the magnitude-error. The author eliminates or at least reduces this error by the use of a number of objective-gratings. When placed in front of the objective, an appropriate grating will give besides the central image of a bright star, two symmetrically placed short spectra, that are nearly stellar. The grating is so chosen that the two secondary images of the bright component of the double star have nearly the same brightness as the central image for the fainter companion. Instead of measuring the central image of the bright component, the measures are made on the two lateral ones and the mean of the two is used. This avoids measurement of stars of different brightness and does away with the main source of systematic errors in this kind of measures.

The author gives complete information about the details of the work at the telescope and at the measuring instrument. Generally a large number of short exposures, sometimes more than one hundred, are secured on the same plate. Exposure times vary from 2 seconds for a 4^m star to 45 seconds for an 8^m star. Not all the images would be measured. Many are distorted through momentary unsteadiness of the seeing or small errors in guiding; only the best ones would be selected for measurement.

The results include 126 pairs, all of the Dorpat Catalogue. The majority of these are wide pairs. The smallest distances recorded are about 1″.2. For all of the pairs the inner agreement seems very satisfactory without however warranting the use of a second decimal place in the position angle, nor a third one in the distance.

For ξ Urs. Maj. the measures are especially numerous; 45 plates were secured during the interval 1914.300—1919.352. The diagram illustrating the results for this pair brings out in a striking way the secondary, short-period motion in 1.8 years.

The results of the measures had been previously published by the author in *Astron. Nachr.* No. 4915-4976.

G. Van Biesbroeck.